PALÆONTOGRAPHICAL SOCIETY.
VOL. LXIV.

GANOID FISHES OF BRITISH CARBONIFEROUS FORMATIONS.

PALÆONISCIDÆ.

PART I, No. 5.

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PART VI.

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THE PALÆONTOGRAPHICAL SOCIETY was established in the year 1847, for the purpose of figuring and describing British Fossils.

Each person subscribing ONE GUINEA *is considered a Member of the Society, and is entitled to the Volume issued for the Year to which the Subscription relates. The price of the Volume to Non-subscribers is* TWENTY-FIVE SHILLINGS NET.

Subscriptions are considered to be due on the 1st of January in each year.

The Annual Volumes are now issued in *two forms of Binding:* 1st, with all the Monographs stitched together and enclosed in one cover; 2nd, with each of the Monographs in a paper cover, and the whole of the separate parts enclosed in an envelope. Members wishing to obtain the Volume arranged in the LATTER FORM are requested to communicate with the Secretary.

Most of the *back volumes* are in stock. Monographs or parts of Monographs already published can be obtained, apart from the annual volumes, from Messrs. DULAU AND CO., LTD., 37, Soho Square, London, W., who will forward a complete price list on application.

Members desirous of forwarding the objects of the Society can be provided with plates and circulars for distribution on application to the Secretary, Dr. A. SMITH WOODWARD, British Museum (Nat. Hist.), South Kensington, London, S.W.

The following Monographs are in course of publication :

The Fossil Sponges, by Dr. G. J. Hinde.

The Graptolites, by Prof. Lapworth, Miss Elles, and Miss Wood.

The Cambrian Trilobites, by Mr. Philip Lake.

The Cretaceous Lamellibranchia, by Mr. H. Woods.

The Palæoniscid Fishes of the Carboniferous Formation, and the Fishes of the Old Red Sandstone, by Dr. R. H. Traquair.

The Fishes of the English Chalk, by Dr. A. Smith Woodward.

GEOLOGY
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ANNUAL REPORT

OF THE

PALÆONTOGRAPHICAL SOCIETY, 1910,

WITH

LIST

OF

The Council, Secretaries, and Members

AND

A LIST OF THE CONTENTS OF THE VOLUMES ALREADY PUBLISHED.

Council and Officers elected March, 1910.

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ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR ENDING 31ST DECEMBER, 1909.

READ AND ADOPTED AT THE

ANNUAL GENERAL MEETING,

HELD AT THE APARTMENTS OF THE GEOLOGICAL SOCIETY, BURLINGTON HOUSE, 18TH MARCH, 1910.

DR. HENRY WOODWARD, F.R.S., PRESIDENT,

IN THE CHAIR.

THE Council, in presenting their Sixty-third Annual Report, are glad to be able to record the usual satisfactory progress in the Society's work. The volume for 1909, which was issued in December, comprises instalments of the Monographs of "Pleistocene Mammalia" ("Canidæ," by Prof. S. H. Reynolds); "Carboniferous Ganoid Fishes," by Dr. R. H. Traquair; "English Chalk Fishes," by Dr. A. S. Woodward; and "Cretaceous Lamellibranchia," by Mr. H. Woods. It also includes title-pages and indexes of two old Monographs—"The Mollusca of the Chalk—Cephalopoda," by Mr. D. Sharpe, and "British Belemnitidæ—Jurassic," by Prof. J. Phillips.

When the volume for the year was planned as many plates were arranged as appeared to be justified by the Society's income, and it was anticipated that the corresponding text would reach the average amount. The nature of the subjects, however, proved to necessitate less text than usual, and the cost of the volume was therefore less than the estimate. Five single and two double plates, to illustrate Carboniferous Fishes, were also paid for by the Carnegie Trust for the Universities of Scotland, to whom the Society's thanks are due. The small balance standing

to the credit of the Society has, in consequence, been augmented during the year, and there is now some provision for unexpected outlays. It has, unfortunately, been necessary during 1909 to pay the sum of £29 8*s*. 7*d*. for the rent and care of lithographic stones for plates which were prepared by authors years ago in anticipation of work which they have not yet completed for publication. It is hoped that arrangements may soon be made for the use of at least some of these stones.

Since the last Annual Meeting the Society has sustained several serious losses by death. The Council mourn more especially the loss of two of their members—the Rev. G. F. Whidborne and Mr. C. Fox Strangways. For many years Mr. Whidborne had been a valuable contributor to the Society's publications, a liberal benefactor, and an active participant in the work of the Council. His Monograph of the Devonian Fauna will always remain an important book of reference, and his memory will long be cherished by those who were associated with him. Mr. Fox Strangways, though for many years a member of the Society and deeply interested in its welfare, only joined the Council a year ago, and his colleagues regret that his term of service is so soon ended. Among other members, the Society has also lost the late Marquis of Ripon and Sir Charles W. Strickland, Bart. A few active members have been added to the roll during the year, but the Council regret that the accessions are still not sufficiently numerous to fill the places left vacant by death.

The thanks of the Society are due to the Council of the Geological Society for permission both to store the stock of back volumes and to hold the Council Meetings and the Annual General Meeting in their apartments.

In conclusion, it is proposed that the retiring members of Council be Mr. Stebbing and Dr. Strahan; that the new members be Miss M. S. Johnston, Rev. R. Ashington Bullen, Dr. F. L. Kitchin, and Mr. A. W. Oke; that the President be Dr. Henry Woodward; the Treasurer, Dr. G. J. Hinde; and the Secretary, Dr. A. Smith Woodward.

Annexed is the Balance-sheet.

The PALÆONTOGRAPHICAL SOCIETY in account with Dr. GEORGE J. HINDE, F.R.S., Treasurer.

Cr. *From January 1st, 1909, to December 31st, 1909.* *Dr.*

		£	s.	d.	£	s.	d.
Balance from last Account					248	16	3
Members' Subscriptions—1906–1908	41	43	1	0			
,, ,, 1909	318	333	18	0			
,, ,, 1910	7	7	7	0			
	366				384	6	0
Carriage paid by Members					2	5	1
Sales of back stock to Members					18	18	8
Sales by Messrs. Dulau & Co., Ltd.					79	16	0
Repaid Income Tax (1 year)					0	15	0
Dividends on £500 Natal 3 per cent. Stock (less income tax)					14	3	9
Interest on Deposit					5	3	5
					£754	4	2

	£	s.	d.	£	s.	d.
Letterpress printing, Vol. LXIII	72	0	10			
Paper	16	17	1			
				88	17	11
Drawing text-figures and making blocks	17	8	6			
Drawing plates	92	10	0			
Collotype and lithographic printing	73	19	4			
Rental and proving lithographic stones	29	8	7			
				213	6	5
Binding Vol. LXIII				37	12	8
Packing and distribution, Vol. LXII				19	4	4
Secretary's honorarium				52	10	0
Postage and stationery				4	13	10
Fire Insurance				0	15	0
Petty charges				1	7	10
Balance at Bank—Current Account	70	1	2			
,, ,, Cheques not cleared	8	8	0			
,, ,, Deposit Account	250	0	0			
				328	9	2
Cash in hand				7	7	0
				£754	4	2

We have examined the above account, compared it with the vouchers, and find it to be correct; we have also seen the receipt for £500 Natal 3 per cent. Consolidated Stock.

March 11th, 1910.

E. T. Newton.
Alfred W. Oke. } Auditors.

LIST OF MEMBERS.*

CORRECTED TO 1st NOVEMBER, 1910.

Aberdeen, University Library.
Adelaide (Australia) Public Library.
Adlard, R. E., Esq., Bartholomew Close. E.C.
Allen, Messrs. E. G. & Son, King Edward Mansions, 14, Grape Street, Shaftesbury Avenue. W.C.
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Amsterdam, Royal Academy of Sciences.
Anderson, Tempest, Esq., M.D., F.G.S., 17, Stonegate, York.
Andrews, C. W., Esq., D.Sc., F.R.S., British Museum (Nat. Hist.), South Kensington. S.W.
Arlecdon and Frizington Public Library, Frizington, Cumberland.
Asher and Co., Messrs., 13, Bedford Street, Covent Garden. W.C.
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Bedford Literary Institute, Bedford.
Belfast Linen Hall Library, Donegal Square North, Belfast.
Belfast, Queen's University.
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Bergen (Norway), Museums Bibliothek.
Birkenhead Public Library, Birkenhead.

* Members are requested to inform the Secretary of any errors or omissions in this list, and of any delay in the transmission of the Yearly Volumes.

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Birmingham Library, Margaret Street, Birmingham.
Birmingham University Library.
Blackburn Public Library, Blackburn.
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Cambridge, Sidney Sussex College.
Cambridge, Trinity College.
Cambridge, University Library.
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Canadian Geological Survey, Sussex Street, Ottawa, Canada.
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Chicago (U.S.A.) Public Library.
Chicago (U.S.A.), University Library.
Chiswick Public Library, Chiswick. W.
Christ Church Public Library, Blackfriars Road, Southwark. S.E.
Christiania (Norway), University Library.
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Leipzig (Germany), University Library.
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Lisbon, Geological Survey of Portugal.
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Malton Field Naturalists' and Scientific Society, Malton, Yorkshire.
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Manchester Literary and Philosophical Society, 36, George Street, Manchester.
Marburg (Germany), University of.
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Metcalfe, Henry F., Esq., Cyprus House, Exmouth.
Middlesbrough Free Library.
Middleton Free Public Library, Middleton, near Manchester.
Milan (Italy), Societa Italiana di Scienze Naturali, Palazzo del Museo Civico.
Mitchinson, Rt. Rev. J., D.C.L., D.D., Canon of Gloucester and Master of Pembroke College, Oxford.
Mond, Robert, Esq., M.A., F.R.S.E., F.G.S., The Elms, Avenue Road, St. John's Wood. N.W.

Munich (Germany), Alte Akademie, Geologisches Museum.
Munich Royal Library.

Nantwich Public Library.
Neumeyer, Dr. Max, Halle-a.-d.-Saale (Germany).
New South Wales, Royal Society of, Sydney.
New York (U.S.A.) Public Library.
Newcastle-on-Tyne, Armstrong College.
Newcastle-on-Tyne, Literary and Philosophical Society of, Westgate Street, Newcastle-on-Tyne.
Newcastle-on-Tyne Public Library.
Newington Public Library, Walworth Road. S.E.
Newport Free Library, Newport, Monmouthshire.
Newton, E. T., Esq., F.R.S., *Vice-President*, Florence House, Willow Bridge Road, Canonbury. N.
North Devon Athenæum, Barnstaple.
North Staffordshire Field Club, Stoke, Staffordshire.
Northampton Natural History Society, Northampton.
Northumberland, His Grace the Duke of, K.G., F.R.S., Alnwick Castle.
Norwich Free Library.
Norwich, Norfolk and Norwich Library.
Nottingham Free Library.

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[1] The Volume for the year 1849 consists of two separate portions, each of which is stitched in a paper cover, on which are printed the dates 1848, 1849, and 1850. The one portion contains 'Cretaceous Entomostraca' and 'Permian Fossils'; the other, 'London Clay Reptilia,' Part II, and 'Fossil Corals,' Part I.

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[1] This Volume is marked on the outside 1855.
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[1] From 1865 onwards the Volumes are issued in two forms of binding: first, with all the Monographs stitched together and enclosed in one cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope. The previous Volumes are not in separate parts.

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- Supplement to the Crag Mollusca, Part II (Bivalves), by Mr. S. V. Wood (pp. 99—231, pls. viii—xi, and add. plate).
- Supplement to the Reptilia of the Wealden (Iguanodon), No. V, by Prof. Owen (pp. 1—18, pls. i, ii).
- Supplement to the Reptilia of the Wealden (Hylæochampsa), No. VI, by Prof. Owen (pp. 1—7).
- The Fossil Reptilia of the Mesozoic Formations, Part I, by Prof. Owen (pp. 1—14, pls. i, ii).

,, XXVIII. Issued July, 1874, for the Year 1874
- The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson (pp. i—v, 1—232, pls. i—xvi).
- The Carboniferous Entomostraca, Part I (Cypridinidæ), by Prof. T. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady (pp. 1—56, pls. i—v).
- The Fossil Trigoniæ, No. II, by Dr. Lycett (pp. 53—92, pls. x—xix).

,, XXIX. Issued Dec. 1875, for the Year 1875
- The Flora of the Carboniferous Strata, Part IV, by Mr. E. W. Binney (pp. 97—147, pls. xix—xxiv).
- The Fossil Echinodermata, Cretaceous, Vol. I, Part VII, by Dr. Wright (pp. 225—264, pls. liii—lxii).
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,, XXX. Issued Dec., 1876, for the Year 1876
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- Supplement to the Fossil Brachiopoda, Vol. IV, Part II, No. 1 (Jurassic and Triassic), by Mr. Davidson (pp. 73—144, pls. ix—xvi).
- Supplement to the Reptilia of the Wealden (Poikilopleuron and Chondrosteosaurus), No. VII, by Prof. Owen (pp. 1—7, pls. i—vi).

,, XXXI. Issued Feb., 1877, for the Year 1877
- Supplement to the Eocene Mollusca (Bivalves), by Mr. S. V. Wood, 2 plates.
- The Fossil Trigoniæ, No. IV, by Dr. Lycett (pp. 149—204, pls. xxviii—xl).
- The Eocene Mollusca (Univalves), Part IV, by Mr. S. V. Wood (pp. 331—361, pl. xxxiv).
- The Carboniferous Ganoid Fishes, Part I (Palæoniscidæ), by Dr. Traquair (pp. 1—60, pls. i—vii).
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,, XXXII. Issued Mar., 1878, for the Year 1878
- The Fossil Echinodermata, Cretaceous, Vol. I, Part VIII, by Dr. Wright (pp. 265—300, pls. lxii A, lxiii—lxix).
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- The Fossil Merostomata, Part V (Neolimulus, &c.), by Dr. H. Woodward (pp. 181—263, pls. xxxi—xxxvi, and title-page).
- Supplement to the Fossil Brachiopoda, Vol. IV, Part II, No. 2 (Jurassic and Triassic), by Mr. Davidson (pp. 145—242, pls. xvii—xxix).
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- Supplement to the Reptilia of the Wealden (Goniopholis, Petrosuchus, and Suchosaurus), No. VIII, by Prof. Owen (pp. 1—15, pls. i—vi).
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- The Fossil Trigoniæ, No. V, by Dr. Lycett (pp. 205—245, pl. xli, and title-page).
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- Supplement to the Reptilia of the Wealden (Goniopholis, Brachydectes, Nannosuchus, Theriosuchus, and Nuthetes), No. IX, by Prof. Owen (pp. 1—19, pls. i—iv).
- The Fossil Elephants, Part II (E. primigenius), by Prof. Leith Adams (pp. 69—146, pls. vi—xv).

,, XXXIV. Issued May, 1880, for the year 1880

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- The Fossil Echinodermata, Oolitic, Vol. II, Part III (Asteroidea and Ophiuroidea), by Dr. Wright (pp. 155—203, pls. xix—xxi, pp. i—iv, and title-page).
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,, XXXV. Issued May, 1881, for the Year 1881

- The Fossil Echinodermata, Cretaceous, Vol. I, Part IX, by Dr. Wright (pp. 301—324, pls. lxx—lxxv).
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- The Fossil Trigoniæ (Supplement No. 1), by Dr. Lycett (pp. 1—4).
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- The Reptilia of the Liassic Formations, Part III, by Prof. Owen (pp. 83—134, pls. xxi—xxxiii, and title-page).
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,, XXXVI. Issued June, 1882, for the Year 1882

- The Eocene Flora, Vol. I, Part III, by Mr. J. S. Gardner and Baron Ettingshausen (pp. 59—86, pls. xii, xiii, and title-page).
- Third Supplement to the Crag Mollusca, by the late Mr. S. V. Wood (pp. 1—24, pl. i).
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- Do., Vol. V, Part I (Devonian and Silurian), by Dr. Davidson (pp. 1—134, pls. i—vii).
- The Lias Ammonites, Part V, by Dr. Wright (pp. 329—400, pls. xlix—lii, lii A, liii—lxix).

,, XXXVII. Issued Oct., 1883, for the Year 1883

- The Eocene Flora, Vol. II, Part I, by Mr. J. S. Gardner (pp. 1—60, pls. i—ix).
- The Trilobites of the Silurian, Devonian, &c., Formations, Part V, by the late Mr. J. W. Salter (pp. 215—224, and title-page).
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,, XXXVIII. Issued Dec., 1884, for the Year 1884

- The Eocene Flora, Vol. II, Part II, by Mr. J. S. Gardner (pp. 61—90, pls. x—xx).
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.. XLIII. Issued Mar., 1890, for the Year 1889	The Cretaceous Entomostraca (Supplement), by Prof. T. Rupert Jones and Dr. G. J. Hinde (pp. i—viii, 1—70, pls. i—iv). The Jurassic Gasteropoda, Part I, No. 4, by Mr. W. H. Hudleston (pp. 193—224, pls. xii—xvi). The Inferior Oolite Ammonites, Part IV, by Mr. S. S. Buckman (pp. 145—224, pls. xxiv—xxxvi). The Devonian Fauna of the South of England, Part II, by the Rev. G. F. Whidborne (pp. 47—154, pls. v—viii, viii A, ix—xv).
,, XLIV. Issued Apr., 1891, for the Year 1890	The Stromatoporoids, Part III, by Prof. Alleyne Nicholson (pp. 159—202, pls. xx—xxv). The Fossil Echinodermata, Cretaceous, Vol. II, Part I (Asteroidea), by Mr. W. Percy Sladen (pp. 1—28, pls. i—viii). The Inferior Oolite Ammonites, Part V, by Mr. S. S. Buckman (pp. 225—256, pls. xxxvii—xliv). The Devonian Fauna of the South of England, Part III, by the Rev. G. F. Whidborne (pp. 155—250, pls. xvi—xxiv). Title-pages to the Supplement to the Fossil Corals, by Prof. Duncan.
,, XLV. Issued Feb., 1892, for the Year 1891	The Jurassic Gasteropoda, Part I, No. 5, by Mr. W. H. Hudleston (pp. 225—272, pls. xvii—xx). The Inferior Oolite Ammonites, Part VI, by Mr. S. S. Buckman (pp. 257—312, pls. xlv—lvi). The Devonian Fauna of the South of England, Part IV (*Conclusion of* Vol. I) (pp. 251—344, pls. xxv—xxxi, and title-page). ,, ,, Vol. II, Part I, by the Rev. G. F. Whidborne (pp. 1—56, pls. i—v).

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,, XLVIII.	Issued Nov., 1894, for the Year 1894	The Jurassic Gasteropoda, Part I, No. 7, by Mr. W. H. Hudleston (pp. 325—390, pls. xxvii—xxxii). Carbonicola, Anthracomya, and Naiadites, Part I, by Dr. W. Hind (pp. 1—80, pls. i—xi). The Inferior Oolite Ammonites, Part IX, by Mr. S. S. Buckman (pp. 377—456, pls. xciii—ciii). The Fishes of the Old Red Sandstone, Part II, No. 1, by Dr. R. H. Traquair (pp. 63—90, pls. xv—xviii).
,, XLIX.	Issued Oct., 1895, for the Year 1895	The Crag Foraminifera, Part II, by Prof. T. R. Jones (pp. 73—210, pls. v—vii). The Jurassic Gasteropoda, Part I, No. 8, by Mr. W. H. Hudleston (pp. 391—444, pls. xxxiii—xl). Carbonicola, Anthracomya, and Naiadites, Part II, by Dr. W. Hind (pp. 81—170, pls. xii—xx). The Devonian Fauna of the South of England, Vol. II, Part IV, by the Rev. G. F. Whidborne (pp. 161—212, pls. xviii—xxiv).
,, L.	Issued Oct., 1896, for the Year 1896	The Crag Foraminifera, Part III, by Prof. T. R. Jones (pp. 211—314). The Jurassic Gasteropoda, Part I, No. 9, by Mr. W. H. Hudleston (pp. 445—514, pls. xli—xliv, and title-page). Carbonicola, Anthracomya, and Naiadites, Part III, by Dr. W. Hind (pp. 171—182, pl. xxi, and title-page). The Carboniferous Lamellibranchiata, Part I, by Dr. W. Hind (pp. 1—80, pls. i, ii). The Devonian Fauna of the South of England, Vol. III, Part I, by the Rev. G. F. Whidborne (pp. 1—112, pls. i—xvi).
,, LI.	Issued Dec., 1897, for the Year 1897	The Crag Foraminifera, Part IV, by Prof. T. R. Jones (pp. vii—xv, 315—402, and title-page). The Carboniferous Lamellibranchiata, Part II, by Dr. W. Hind (pp. 81—208, pls. iii—xv). The Carboniferous Cephalopoda of Ireland, Part I, by Dr. A. H. Foord (pp. 1—22, pls. i—vii). The Devonian Fauna of the South of England, Vol. III, Part II, by the Rev. G. F. Whidborne (pp. 113—178, pls. xvii—xxi).
,, LII.	Issued Dec., 1898, for the Year 1898	The Palæozoic Phyllopoda, Part III, by Prof. T. R. Jones and Dr. Woodward (pp. 125—176, pls. xviii—xxv). The Carboniferous Lamellibranchiata, Part III, by Dr. W. Hind (pp. 209—276, pls. xvi—xxv). The Inferior Oolite Ammonites, Part X, by Mr. S. S. Buckman (pp. i—xxxii, Suppl. pls. i—iv). The Carboniferous Cephalopoda of Ireland, Part II, by Dr. A. H. Foord (pp. 23—48, pls. viii—xvii). The Devonian Fauna of the South of England, Vol. III, Part III, by the Rev. G. F. Whidborne (pp. 179—236, pls. xxii—xxxviii).

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„ LV.	Issued Dec., 1901, for the Year 1901	The Cretaceous Lamellibranchia, Part III, by Mr. H. Woods (pp. 113—144, pls. xx—xxvi). The Carboniferous Lamellibranchiata, Vol. II, Part I, by Dr. W. Hind (pp. 1—34, pls. i—vi), Title-page and Index for Vol. I. The Carboniferous Cephalopoda of Ireland, Part IV, by Dr. A. H. Foord (pp. 127—146, pls. xxxiii—xxxix). British Graptolites, Part I, by Miss Elles and Miss Wood, edited by Prof. Lapworth (pp. 1—54, pls. i—iv). Ganoid Fishes of British Carboniferous Formations—Part I, Palæoniscidæ, No. 2, by Dr. Ramsay H. Traquair (pp. 61—87, pls. viii—xviii).
„ LVI.	Issued Dec., 1902, for the Year 1902	The Cave Hyæna, by Prof. S. H. Reynolds (pp. 1—25, pls. i—xiv). The Fishes of the English Chalk, Part I, by Dr. A. Smith Woodward (pp. 1—56, pls. i—xiii). The Cretaceous Lamellibranchia, Part IV, by Mr. H. Woods (pp. 145—196, pls. xxvii—xxxviii). British Graptolites, Part I, No. 2, by Miss Elles and Miss Wood, edited by Prof. Lapworth (pp. i—xxviii, 55—94, pls. v—xiii).
„ LVII.	Issued Dec., 1903, for the Year 1903	The Fishes of the English Chalk, Part II, by Dr. A. Smith Woodward (pp. 57—96, pls. xiv—xx). The Cretaceous Lamellibranchia, Part V, by Mr. H. Woods (pp. i—xliii, 197—232, pls. xxxix—xlii), Title-page and Index for Vol. I. The Carboniferous Lamellibranchiata, Vol. II, Part II, by Dr. W. Hind (pp. 35—124, pls. vii—xxi). The Carboniferous Cephalopoda of Ireland, Part V, by Dr. A. H. Foord (pp. 147—234, pls. xl—xlix), Title-page and Index. The Lower Palæozoic Trilobites of Girvan, Part I, by Mr. F. R. Cowper Reed (pp. 1—48, pls. i—vi). British Graptolites, Part III, by Miss Elles and Miss Wood, edited by Prof. Lapworth (pp. xxix—lii, 103—134, pls. xiv—xix).
„ LVIII.	Issued Dec., 1904, for the Year 1904	The Fishes of the Old Red Sandstone, Part II, No. 2, by Dr. R. H. Traquair (pp. 91—118, pls. xix—xxvi). The Cretaceous Lamellibranchia, Vol. II, Part I, by Mr. H. Woods (pp. 1—56, pls. i—vii). The Carboniferous Lamellibranchiata, Vol. II, Part III, by Dr. W. Hind (pp. 125—216, pls. xxii—xxv). The Inferior Oolite Ammonites, Part XII, by Mr. S. S. Buckman (pp. lxv—clxviii, pls. xv—xix). The Lower Palæozoic Trilobites of Girvan, Part II, by Mr. F. R. Cowper Reed (pp. 49—96, pls. vii—xiii). British Graptolites, Part IV, by Miss Elles and Miss Wood, edited by Prof. Lapworth (pp. liii—lxxii, 135—180, pls. xx—xxv).

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„ LX. Issued Dec., 1906, for the Year 1906

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„ LXI. Issued Dec., 1907, for the Year 1907

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Palæontographical Society, 1910.

THE

GANOID FISHES

OF THE

BRITISH CARBONIFEROUS FORMATIONS.

BY

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PART I, No. 5.

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and "small"; in ordinary specimens the large ones measure about $\frac{1}{24}$ inch in length, and the others, very minute, are clearly seen in one specimen to occupy a more external position on the edge of the jaw.

The bones of the shoulder-girdle do not call for special remark.

The pectoral and ventral fins are very small; the latter are placed nearly midway between the pectorals and the anal. The dorsal is placed very far back, being nearly opposite the anal, which it resembles both in size and in shape; both are triangular-acuminate, with the posterior margin rather concave. To count the fin-rays in such delicate little fossil fishes is rather a difficult and uncertain matter, but I would estimate the number in the dorsal and anal fins at about thirty for each, of which the posterior ten are very fine. They do not bifurcate till near their terminations; their transverse articulations are rather distant, especially near the attachment of the fin; minute fulcra, rather thinly set, may be seen along the anterior margins. The caudal is deeply bifurcated and inequilobate; the fulcral scales along the anterior margin of the lower lobe are more distinct and closely set than those of the other fins. About eighteen or nineteen rays go to form the lower lobe; the rest become exceedingly fine and delicate as we proceed towards the tip of the upper lobe.

As regards the scales, Prof. J. Young referred to them as being "cycloidal," but remarked further that "the obliquity of their axis, from the production of their postero-inferior angle, gives them *in situ* a rhomboidal appearance." Mr. Barkas also stated that they were "cycloidal" and that they "more closely resemble those of *Cœlacanthus* than do the scales of any other Coal Measure fishes." They are, however, in reality rhomboidal, and conform in every essential respect to the type of scales seen in *Palæoniscus* and its allies. Their principal peculiarities are their thinness, the rounding of their postero-inferior angles, and their upper margins being, perhaps, rather more than usually overlapped. The form of a flank-scale (Pl. XXVII, fig. 5) is rhomboidal, with the antero-superior angle acute and pointed, the postero-inferior rounded; from the middle of the superior margin a pointed peg projects upwards for articulation with the under surface of the scale above. The ornament of the free surface consists of fine, raised, thread-like ridges running in the main parallel with the anterior, inferior, and posterior margins, of which arrangement the drawing fig. 4 will give a better idea than any further description. One ridge running along the upper part of the posterior margin is generally more or less zigzagged so as to give almost a crenulated appearance to that margin. The scales of the flank do not alter much in size or shape till we come to the small and acutely lozenge-shaped ones which clothe the sides of the caudal body-prolongation, the upper margin of which is bordered by the usual median series of V-shaped scales. The scales of the back and belly are smaller than those of the sides; azygous, somewhat heart-shaped scales are often seen in the mesial dorsal line where the oblique rows of each side meet, but I do not see any specially large ones in front of the dorsal fin as in *Palæoniscus*, etc. The lateral line is very distinctly traceable from the

shoulder-girdle to the origin of the lower lobe of the caudal fin, the scales which it traverses being each marked with a slight ridge or elevation, which disturbs very considerably the regularity of the proper striæ of the scale.

Remarks.—The MS. name *Cycloptychius carbonarius*, devised by Prof. Huxley for this beautiful little fish, was adopted by Prof. J. Young in his brief description. Its characters are so distinct that I think there is scarcely any danger of its being confused with any other species.

Geological Position and Localities.—An Upper Carboniferous fish principally found in the Coal Measures (Deep Mine Ironstone Shale) of Longton and Fenton in North Staffordshire, where most of the specimens known were collected by the late Mr. John Ward, F.G.S. The species has also been recorded from Northumberland by Barkas and from Yorkshire by Wellburn.[1] The types are in the Ward Collection, British Museum.

2. Cycloptychius concentricus, *Traquair*. Plate XXVII, figs. 6—9.

Cycloptychius concentricus, *Traquair*. Trans. Roy. Soc. Edinb., vol. xxx, 1881, p. 37, pl. ii, figs. 17—20.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 461.

Specific Characters.—Postero-inferior angle of flank-scales obtuse; ridges on the scales proportionately coarser than in *C. carbonarius;* nearly concentric on the flank-scales; no zigzagged line at posterior border; scales of the back low and having in the central area a few diagonal ridges passing obliquely from before downwards and backwards.

Description.—Attaining a length of $4\frac{3}{4}$ inches; the specimen shown in Pl. XXVII, fig. 6, measures $4\frac{1}{4}$ inches. The length of the head is contained about five times, the greatest depth of the body over six times in the total length up to the extremity of the upper caudal lobe. The contour of the fish is therefore peculiarly slender and graceful, the depth of the body continuing pretty uniform as far as the origin of the posteriorly placed dorsal fin, whence it tapers to the moderately stout tail-pedicle.

The head is somewhat elongated, with very oblique suspensorium, extensive gape, anteriorly placed orbit and well-marked ethmoidal prominence. The sculpture of the cranial roof-bones is not exhibited; on the other bones of the head it is of a striated character, but is only well seen in the case of the maxilla and mandible. The former has its broad post-orbital portion covered with closely set ridges which pass into an irregular tuberculation along the dentary margin; the mandible, slender and tapering in shape, has also a narrow band of tuberculation along its upper margin, but below this the surface is striated with fine ridges which proceed diagonally from above downwards and

[1] 'Proc. Yorks. Geol. and Polytechnic Society,' vol. xiv, pt. ii, 1901, p. 168.

forwards, and increase in obliquity from behind forwards. Small conical teeth of different sizes may be observed in several specimens.

The bones of the shoulder-girdle present nothing peculiar in their configuration, and so far as their external sculpture is visible it consists of wavy sub-parallel ridges.

The scales of the flank (fig. 7) are somewhat large for the size of the fish, and are higher than broad, with their postero-inferior angles obtuse; towards the back, belly, and tail they become smaller, and assume the usual rhomboidal shape. The articular spine is well marked though small; the keel of the attached surface is central and sharply defined. The scale-markings are characteristic. Along the sides of the body, as far as the tail-pedicle, the exposed surface of the scale is ornamented by somewhat coarse and closely placed ridges, which, commencing at the upper margin, descend in such a way as to form one median ridge surrounded by several others, which, running parallel with each other and with the anterior and posterior margins, join each other below round the extremity of the median one; or—to put the matter in a different way—we have a set of concentric ridges parallel with the antero-inferior and posterior margins with an odd one in the middle, or sometimes with two uniting in a loop; in addition, there are often one or two fine vertical striæ along the anterior margin. A somewhat different pattern is observable along the back (fig. 8), extending downwards to and including the second longitudinal row of scales above the lateral line. Here there is ordinarily only one marginal ridge, running closely along the anterior, inferior, and posterior borders, within which the area is, according to the size of the scale, occupied by from two to five diagonal and parallel ridges passing from before downwards and backwards. The caudal body-prolongation has its minute lozenge-shaped scales ornamented by diagonal ridges only; striæ of a similar description characterise also the large V-shaped scales which run along its upper margin.

The *pectoral* fin is small, its length being hardly more than half that of the head; it is acuminate in shape and consists of about twelve rays, of which the principal ones are unarticulated till towards their terminations. The *ventrals* seem to have been likewise small, and the articulations of their rays somewhat distant. The median fins are on the contrary of tolerably large size. The *dorsal* is situated far back, and is triangular-acuminate in shape; its rays, the number of which cannot be accurately ascertained, are slender, smooth, and distantly articulated. The *anal* is placed nearly opposite the dorsal; it is sharply acuminate, with concavely excavated posterior border; the rays are of the same character as those of the dorsal. The *caudal* fin is well developed, deeply cleft, and inequilobate; its rays resemble those of the other median fins.

Remarks.—That the above described species is referable to the genus *Cycloptychius* is indicated by the following characters: The slender, elongated form of the body, the backward position of the dorsal fin, the obtuseness of the postero-inferior angles of the scales, and, last but not least, the possession of a peculiar scale-ornament, consisting of ridges running parallel with the anterior, inferior and posterior margins of the scale. At

the same time the differences between it and *Cycloptychius carbonarius* are apparent at the first glance. In *C. carbonarius* the ridges on the scales are much finer, the one along the posterior margin being also more or less zigzagged in contour, while there is not that difference in the sculpture of the scales along the back, which is so prominent a character in *C. concentricus*. The shape of the flank-scales also differs to a considerable extent; for while in the former species the postero-inferior angles are simply rounded off, in *C. concentricus* they are absolutely obtuse, so that the inferior margin looks as much backwards as downwards.

Geological Position and Locality.—A Lower Carboniferous fish, and as yet only known from the Calciferous Sandstone Series at Glencartholm, Eskdale.

The type is in the Collection of the Geological Survey of Scotland.

Genus—Rhadinichthys, *Traquair*, 1877.

Palæoniscus (pars), *Agassiz*.

Generic Characters.—Body fusiform, often elongate-fusiform; caudal body-prolongation usually weak; body-scales rhombic, usually, but not always, denticulated posteriorly, their overlapped surface narrow. Principal rays of pectoral fin unarticulated till towards their terminations; dorsal situated rather far back, commencing only slightly in front of the anal, sometimes indeed directly opposed to the anal; caudal deeply cleft and inequilobate. Suspensorium very oblique, gape large; operculum oblong; suboperculum quadrate; branchiostegal rays or plates numerous, with a median lozenge-shaped plate behind the symphysis of the mandible as in *Elonichthys*, *Gonatodus*, etc. Jaws armed with a set of incurved conical laniaries, outside which there is a series of smaller teeth.

Remarks.—I proposed this genus in 1877 for the reception of the "*Palæoniscus*" *ornatissimus* and *P. carinatus* of Agassiz, which, on account of the condition of the pectoral fin-rays and the backward position of the dorsal fin, could not be included either in that genus or in *Elonichthys*. As referable to the same category I also noted "*Palæoniscus*" *Wardi* (Ward) from the British Upper Carboniferous, and "*Palæoniscus*" *Cairnsi* and *Alberti* of Jackson from the Lower Carboniferous of New Brunswick, while in the year after I also added "*Palæoniscus*" *monensis* of Egerton to the new genus. The number of species referred to *Rhadinichthys* has since those days been on the increase. No less than twenty-six names of species, including synonyms, are enumerated by Dr. Smith Woodward in his Catalogue (Pt. ii, 1891), of which five are from the American continent. More recently "*Palæoniscus*" *devonicus* of Clarke has been added to *Rhadinichthys* by Eastman, who has likewise described a new species also from the American Upper Devonian, to which he has given the name of *Rhadinichthys Deani*.[1] This species is remarkable as having furnished a number of heads in which the form of

[1] Eastman, 'Geol. Survey, Iowa,' vol. xviii, 1908, pp. 258-60, and 264-272.

the brain and the details of the labyrinth of the ear are preserved, even a few blood-vessels being traceable. I may anticipate a little by stating that in a specimen of *Rh. carinatus* (Ag.) in my possession, one of the semicircular canals and also an otolith are distinctly shown.

In form and fins *Rhadinichthys* has affinities with *Cycloptychius*, but the scales are angulated all over the body, none of their corners being rounded off. Also, though on a small scale, this genus recalls the Permian *Pygopterus*, but the anal fin is not produced backwards in a fringe-like manner, as it is in the last-named form.

It is pre-eminently a Carboniferous genus, the only exceptions to this position being the *Rhadinichthys devonicus* (Clarke) and *Rh. Deani*, Eastman, from the Upper Devonian of New York and Kentucky respectively.

1. Rhadinichthys ornatissimus, *Agassiz*, sp. Plate XXVIII.

Palæoniscus ornatissimus, *Agassiz*. Poiss. Foss., vol. ii, pt. i, 1835, p. 92, pl. x *a*, figs. 6, 8 (*non* figs. 5, 7).

Rhadinichthys ornatissimus, *Traquair*. Quart. Journ. Geol. Soc., vol. xxxiii, 1877, p. 559. Also Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 432; Proc. Roy. Soc. Edinb., vol. xvii, 1890, pp. 391, 397; Distrib. of Fossil Fish-remains in the Carb. Rocks of the Edinburgh District (Trans. Roy. Soc. Edinb., vol. xl, pt. iii, No. 28), pp. 690, 691, 692, etc.

— lepturus, *Traquair*. Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 437.

— ornatissimus, *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 462.

Specific Characters.—Occasionally attaining a length of ten inches. Length of head contained about one-fifth in the total; external head-bones sharply striated. Scales rather large, those of the flank ornamented with numerous sharp and slightly sigmoidal ridges and furrows, whose direction is mostly parallel with the upper and lower margins, and ending in denticulations of the posterior border. Paired fins rather small; median fins well developed, articulations of the rays rather distant; fulcra distinct; body prolongation in upper lobe of caudal fin weak.

History.—"*Palæoniscus*" *ornatissimus* was described by Agassiz from three specimens, all of which are figured in the 'Poissons Fossiles.' Two of these from Burdiehouse are in the collection of the Royal Scottish Museum, Edinburgh; they are in a very bad state of preservation, though enough is seen of their structure to convince one that they belong to two different species. The original of fig. 5, tab. 10 *a*

('Atlas,' vol. ii) seems to be only a peculiarly crushed specimen of *Elonichthys Robisoni*. The other, represented in fig. 6, is of larger dimensions, and though the fins are imperfectly shown, yet, from the general form of the body and from the sculpture of the scales and cranial bones, I have no hesitation in identifying with it a fish which has turned out to be very common in the Lower Carboniferous rocks around Edinburgh. The specimen represented in fig. 7 of the same plate of Agassiz's work does not seem to belong to the same species, and unfortunately, there seems now to be no hope of tracing the original to its present possessor, as it belonged to the late Mr. Jameson Torrie, whose collection was, after his death many years ago, sold by public auction and dispersed. As type of "*ornatissimus*" we are therefore justified in taking the original of fig. 6 of the plate referred to, and that we have in this "*ornatissimus*" the type of a very well-marked genus will, I think, not be disputed.

Description.—The length of the type specimen, which is so bent round that the tip of the tail nearly touches the snout, is five inches; doubtless its original length was greater previous to the strange contortion, which has thus affected its form. It is, nevertheless, small, as the most perfect example in the Hugh Miller Collection (Pl. XXVIII, fig. 2) attains an estimated length of eight inches, while another, unfortunately wanting the head, would probably have measured no less than ten inches had it been entire. The best view of the external form and proportions is afforded by the specimen from Straiton, represented in fig. 1 of the same plate, which would be five inches in length if we allow for the little bit of the extremity of the upper lobe of the caudal fin which is wanting. The length of the head is contained about one-fifth in the total and is slightly greater than the greatest depth of the body. The suspensorium is very oblique, the gape extensive; the lower jaw (fig. 4) is stout, but tapering. Traces of sharp conical teeth are seen in many specimens, and are, as usual, arranged in two sets, internal larger and external smaller. The operculum (*op.*, Text-fig. 6) is large and oblong, with acute antero-superior and postero-inferior angles; the suboperculum (*s.op.*) is of the usual quadrate shape. A specimen from Wardie, obliquely compressed upon its back, and of which the head is represented in Pl. XXVIII, fig. 3, shows on the right side a beautiful series of fifteen branchiostegal rays or plates, along with the anterior seven of those of the other side, besides which there is a small median lozenge-shaped plate (*br.''*) behind the symphysis of the jaw, the anterior plate (*br.'*) of each lateral series being also much broader than the others. All the bones of the head are finely and closely striated.

The scales are rather large on the front of the flank. In a Burdiehouse specimen, which probably measured originally about ten inches in length, one of these scales measures two-fifths of an inch in height by three-tenths of an inch in breadth; they get much smaller posteriorly, and those situated on the belly are rather low and narrow. Their external ornament (fig. 5, taken from a Straiton specimen) consists of numerous sharp, yet delicate, slightly sigmoidally curved ridges and furrows, which are mostly

parallel with the superior and inferior margins. In the furrows between these ridges numerous punctures may be observed, and often about the centre of the scale the ridges are over a small space nearly obsolete, so that the punctures come more prominently into view, and the ridges themselves end in fine denticulations of the hinder margin. Fig. 6 represents a scale taken from further back, in which the ridges are fewer and more oblique, passing, however, anteriorly into very fine striæ, while in fig. 7 we have another posterior scale in which the coarser ridges have disappeared, and their place is altogether taken by fine oblique striæ.

The paired fins are rather small, the pectoral attaining only about one-half the length of the head. It is well shown in the specimen represented in Pl. XXVIII, fig. 2, and consists of about thirty rays, of which the principal ones are, as in *Pygopterus* and *Oxygnathus*, unarticulated till towards their terminations. The ventral is placed nearer to the anal than to the pectoral. The dorsal and anal fins are moderate, the former

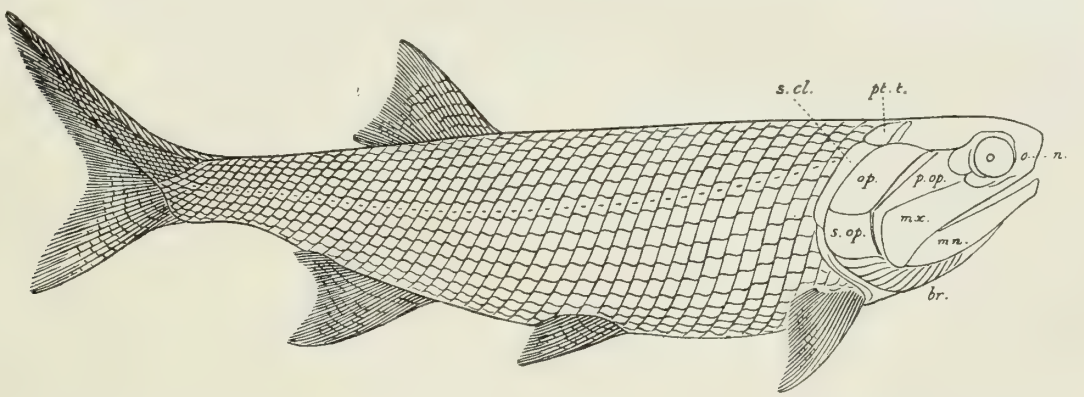


FIG. 6.—Restored outline of *Rhadinichthys ornatissimus* (Agassiz). *o.*, orbit; *op.*, operculum; *p.op.*, preoperculum; *s. op.*, suboperculum; *br.*, branchiostegal plates; *mx.*, maxilla; *mn.*, mandible; *cl.*, clavicle; *s.cl.*, supraclavicular; *pt. t.*, post-temporal. The fin-fulcra have been omitted, being too minute for a drawing on so small a scale.

being placed far back and arising only slightly in front of the anal; both are acuminate, triangular, with concave posterior margins. It is not possible to ascertain the number of rays in these fins. They are rather delicate, and having their transverse joints about twice as long as broad—at least in the longer rays before bifurcation—when the rays are *in situ* their articulations appear proportionately still more distant (fig. 8) owing to the imbrication of the demi-rays. The tail-pedicle is rather long; the caudal body-prolongation is weak, and the lower lobe of the caudal fin is largely developed. The anterior rays of this lower lobe are stouter than those of the rest of the fin and have their transverse articulations closer, the joints appearing nearly square as seen from the outside; as the lower lobe passes into the upper one the rays become more delicate and their articulations more distant. The outer surfaces of the joints of these fins are mostly smooth, though showing here and there traces of longitudinal striation (see fig. 8), especially towards their proximal extremities. The fulcra are small, though very distinctly visible under an ordinary lens.

Observations.—I had after careful consideration come to the conclusion that my *Rh. lepturus* from Burntisland ('Proc. Roy. Soc. Edinb.,' vol. ix, 1877, p. 437) was only a young and imperfectly preserved specimen of *Rh. ornatissimus*, and accordingly in 1890 I cancelled the species (ibid., vol. xvii, p. 397). In reality there is no more distinct and easily recognised species in the whole family of Palæoniscidæ, and as I have already remarked, its position as the type of a distinct and extensive genus is unmistakable.

Geological Position and Localities.—Only in the Lower Carboniferous Rocks of the central valley of Scotland, in which, however, its vertical range is very extensive.

Calciferous Sandstone Series: in ironstone nodules washed out of the shales at Wardie Beach; in shale exposed in the Water of Leith, near Slateford, and near Juniper Green; at Lochend, near Edinburgh. In the Burdiehouse Limestone at Burdiehouse, and at South Queensferry. Abundant in nodules in the "roof" of the "Dunnet" Shale formerly worked at Straiton and Old Pentland; sparingly found in the shale itself. In West Lothian, in the "Dunnet" Shale, near Broxburn. In Fifeshire at Burntisland, and at Kiness Burn, near St. Andrews. In East Lothian, near Gullane.

Lower Limestone Series: East Kilbride, Lanarkshire. Specimen formerly in the Hunter Collection, Kilmarnock Museum.

Edge Coal Series: in the Borough Lee Ironstone, Loanhead, near Edinburgh; also in the roof-shale of the "Flex" Coal, worked at the same locality, but very rare.

2. Rhadinichthys carinatus, *Agassiz*, sp. Plate XXIX, figs. 1—6.

Palæoniscus carinatus, *Agassiz*. Poiss. Foss., vol. ii, pt. i, 1835, p. 104, pl. iv *c*, figs. 1—2.

Rhadinichthys Geikiei, *Traquair*. Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 438 (*non* Trans. Roy. Soc. Edinb., vol. xxx, 1881, p. 25, pl. ii, figs. 1—5).

— carinatus, *Traquair*. Ibid., p. 441; also in Quart. Journ. Geol. Soc., vol. xxxiii, 1877, p. 559, and in Proc. Roy. Soc. Edinb., vol. xvii, 1890, pp. 391 and 397.

— tenuicauda, *Traquair*. Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 443.

carinatus, *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 463.

— tenuicauda, *A. S. Woodward*. Ibid., p. 466.

Specific Characters.—Form elegant and slender; the length of the head contained somewhat over five times in the total, and equal or thereabout to the greatest depth of the body at the ventral fins. Cranial bones finely striated. Scales rather large on the flank, usually smooth, with a few punctures, and having the posterior border sharply denticulated with from seven to eleven points; in some cases the notches between the

denticulations are continued forwards for some distance over the surface as little grooves —the scales immediately behind the shoulder, along the middle of the back as far as the dorsal fin, and along the middle line of the belly as far as the ventrals, being also sometimes more or less striated. The paired fins are small, the median fins rather large, and the caudal body-prolongation weak.

Description.—The general form is slender, though, owing to *post-mortem* changes, the exact proportions vary constantly in different individuals, as may be seen on comparing the two specimens represented in Pl. XXIX, figs. 1 and 2; on the whole, however, the length of the head seems to be contained a little over five times in the total, and to be equal to the greatest depth of the body at the ventral fins. The bones of the cranial shield are ornamented with sharp delicate wavy ridges or striæ. A specimen in my collection shows most clearly the presence of extensive ossification in the periotic and alisphenoid region of the cranium, and, moreover, a cast of the posterior semicircular canal of the ear is most distinctly and beautifully preserved. The external ornament of the facial bones consists, like that of the cranial shield, of delicate wavy ridges. The paired fins are small; there is, in the case of the pectorals, sufficient evidence (fig. 3) that the principal rays were unarticulated till towards their terminations; the ventrals, seldom seen, are placed halfway between the pectorals and the anal. The median fins may be considered rather large in proportion to the size of the fish. The anal commences rather in front of a point equidistant between the origin of the ventrals and that of the lower lobe of the caudal; it is high and acuminate in front, with its posterior border rather concave. The dorsal is similar in shape to the anal and commences only slightly in front of the origin of the latter. The caudal is deeply cleft; the lower lobe well developed; but, as in the previously described species, the prolongation of the body-axis along the upper lobe is comparatively delicate. The rays of all these fins are slender, with distant articulations, their exposed surfaces being ganoid and smooth; the fulcra along the anterior margins of the fins are obvious though minute.

The scales are rather large and quadrate on the flanks, but towards the median ventral line they become low and narrow. A typical flank-scale, magnified, is represented in Pl. XXIX, fig. 5, and shows a brilliantly polished ganoid surface with some scattered punctures, and along the posterior margin some seven to eleven sharp denticulations. In some specimens, however, a certain amount of striation is produced (fig. 6) by the notches between the denticles being produced forwards for a little way over the surface; in some examples, indeed, this striation is found over all the scales of the anterior part of the flank. In every case, however, the scales of the nape of the neck (fig. 4) seem to be striated all over, and a certain amount of striation is also frequently observed on the narrow scales along the ventral margin between the pectoral and ventral fins.

Observations.—The type specimen of "*Palæoniscus*" *carinatus*, collected by Lord Greenock, and described and figured by Agassiz, is now in the Royal Scottish Museum,

having been presented to that institution by the Royal Society of Edinburgh. It is very imperfect, showing no fins save the mere origins of the anal and caudal, the former of which seems to have been overlooked by Agassiz. On the other hand, I cannot, by the most careful examination, verify his statement regarding the presence of small teeth "*en brosse*" upon the jaw.

Imperfect though the type specimen may be, I am nevertheless justified in identifying with it not only some examples from the original locality, but also many others from various places and horizons, which show very clearly that "*carinatus*" is a well-marked member of the genus *Rhadinichthys*. Its characters as regards the scale ornament are rather more variable than in the case of *Rh. ornatissimus*, and accordingly there is here more danger of unnecessary multiplication of species. I have in this way seen reason to retract the specific term *Geikiei* which I applied to some very small and apparently juvenile specimens collected by the Geological Survey of Scotland at Redhall, near Slateford, as well as to consider my *Rh. tenuicauda* to be founded on unsatisfactorily preserved examples of the species under consideration.

In the Edinburgh University Anatomical Museum there is a specimen of *Rh. carinatus* from Cornceres, in Fifeshire, which belonged to the late Professor Goodsir; it is possible that this may be the "*Catopterus fusiformis*" which the late Mr. Robert Walker states was described by Professor Goodsir in 1838 before a meeting of the Literary and Philosophical Society of St. Andrews, and which, according to Mr. Walker, he characterised as being closely allied to *Palæoniscus*, but differing from it "in wanting the scaling or false rays along the anterior ray of the fins, and also in the dorsal fin being opposite the anal."[1] In this specimen the dorsal fin is, indeed, nearly opposite the anal (as in others of the same genus as well as species), but on close examination fulcra are distinctly observable. I have not been able to procure Professor Goodsir's description, or even to ascertain exactly where it is to be found, but as it appears to have been published only in a provincial newspaper, the generic name *Catopterus* must remain with the Triassic semi-heterocercal fishes for which it was proposed by the Messrs. Redfield.[2]

Geological Position and Localities.—Like the preceding species, *Rhadinichthys carinatus* has an extensive distribution in the Lower Carboniferous rocks of the great central valley of Scotland. The following is a list of localities arranged in geological succession from below upwards:

Calciferous Sandstone Series: Wardie Beach, in ironstone nodules. Redhall, near Slateford, in railway cutting; floor of "Dunnet" Shale at Straiton. Abundant in the "Curly" Shale at Pumpherston and Roman Camp, in the Broxburn district, West Lothian. In Fifeshire, at Burntisland; Cornceres near Kilrenny; Pitcorthy near Anstruther.

[1] 'Trans. Geol. Soc. Edinb.,' vol. ii, 1872, p. 124.

[2] *Catopterus*, J. H. Redfield, was likewise published by the American author one year earlier, namely in 1837.

Edge Coal Series: in shale accompanying an ironstone near the "North" Coal worked at Niddrie, near Edinburgh; Borough Lee Ironstone, Loanhead; Wallyford, near Musselburgh.

3. Rhadinichthys canobiensis, *Traquair*.

Rhadinichthys Geikiei, *Traquair*. Trans. Roy. Soc. Edinb., vol. xxx, 1881, p. 25, pl. i, figs. 13—18 (*non* Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 438).
— — var. elegantulus, *Traquair*. Ibid., p. 27, pl. ii, figs. 1—5.
— delicatulus, *Traquair*. Ibid., p. 29, pl. ii, figs. 6—9.
— elegantulus, *Traquair*. Ann. and Mag. Nat. Hist. [6], vol. vi, 1890, p. 492.
— — with variety delicatulus, *Traquair*. Proc. Roy. Soc. Edinb., vol. xviii, 1890, p. 398.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 464.

History.—In my original essay on the Eskdale Ganoids, I identified the common *Rhadinichthys* of the Glencartholm fish-beds with the little Redhall fish, to which I had in 1877 given the name of "*Rh. Geikiei*," including, as a "variety," a form which I named "*elegantulus*," while I accorded the rank of a species to another closely allied fish, namely *Rh. delicatulus*.

Afterwards, in 1890, I published my conviction that "*Geikiei*" was only a synonym of "*carinatus*," and therefore proposed to adopt "*elegantulus*" as the name of the Eskdale species including "*delicatulus*" as a variety. In this adjustment of the nomenclature Dr. Smith Woodward, in the second part of his Catalogue, acquiesced.

Since that time it has, however, struck me that the name "*elegantulus*," having been originally proposed to designate a *variety*, must remain confined to that variety, which may indeed be elevated into a species by some future investigator, who may take up the special study of these forms. According to this view a name is now wanting for the species as a whole, and for that I beg to suggest the term "*canobiensis*."

General Characters of the Species.—Fishes resembling *Rh. carinatus* in general form and dimensions, but having the denticulations of the posterior margins of the scales fewer and coarser.

A. The Typical Form. Plate XXX, figs. 1—6.

Description.—Perfect specimens usually measure from 4 to 4½ inches in length; a somewhat larger size is, however, sometimes indicated by examples of a more fragmentary description. The shape is elegantly fusiform and rather slender; the length of the

head being rather greater than the depth of the body at the ventral fins, and contained about four and a half times in the total.

The cranial roof-bones are ornamented with closely set, well-defined elevated ridges, which, although wavy and somewhat contorted, mainly follow a longitudinal direction, especially on the parietal and frontal plates and the posterior part of the superethmoidal; they are often bifurcated, intercalated and interrupted, and on the lateral parts of the cranial shield these interruptions often become so frequent as to cause the ornament to assume a somewhat tubercular character, which in some cases invades even the more central parts. On the anterior part of the superethmoidal, which forms the usual projection over the mouth, the ridges are disposed transversely.

The direction of the suspensorium is very oblique, and the gape consequently wide. The opercular bones are well developed and of the usual shape in this genus, but their external markings are not distinctly preserved. The maxilla has its broad portion ornamented with fine ridges, which run parallel with its superior and posterior margins; its infra-orbital process is tuberculated, and the tubercles are continued backwards as a narrow band along the entire inferior or dentary margin of the bone. The beautifully tapering mandible is covered externally with fine ridges which pass forward from the angle in a somewhat radiating manner, so that below they are pretty parallel with the inferior margin, while above they cut the superior one at low angles. In large specimens these ridges break up into minute tuberculation along the superior margin of the jaw —a condition rarely met with in the smaller examples. The orbit is anteriorly placed, and furnished with the usual arrangement of suborbital and circumorbital plates.

The bones of the shoulder-girdle are ornamented with well-defined sub-parallel ridges, which are arranged according to the common pattern, namely somewhat concentrically, and more or less parallel with the margins of the bones.

The scales are of moderate size with narrow covered area, rhomboidal in shape and increasing in obliquity, and diminishing in size towards the tail. On the flank they are tolerably equilateral, but along the belly between the pectoral fins and the posterior part of the base of the anal they suddenly become very low and narrow, their height diminishing to one-half or one-third of their length. This change of form usually occurs at the fourth or fifth scale downwards from the lateral line. A few large scales are seen in front of the dorsal, anal, and lower lobe of the caudal fin, while on the body-prolongation in the upper lobe of the latter the usual modifications of shape occur.

As regards the scale-markings, their general plan may be described as follows: Taking a scale from the anterior part of the flank (Pl. XXX, figs. 2, 3), a few delicate grooves are seen passing down along the anterior margin of the ganoid area, and then at the antero-inferior angle, turning round so as to become parallel with the inferior margin. The rest of the area presents, according to the size of the specimen, from four to seven longitudinal elevations or feeble ridges running across the scale with a slight downward obliquity as well as a slight tendency to radiation, and ending on as many

sharp denticulations of the hinder margin. Towards the back and belly (fig. 5) both sets of markings tend to become confounded into one set of delicate, more or less diagonal ridges and grooves, while towards the tail (fig. 4) these markings usually fade away, a few punctures and longitudinal furrows being in most cases all that is to be seen on the scales behind the dorsal and anal fins. In different individuals, however, very considerable differences are to be found as regards the strength and prominence of the scale-markings. In some the markings are very distinctly and sharply defined (fig. 2) and the scales continue to be highly ornate up to the caudal body-prolongation, while in others (fig. 3) even the scales on the front part of the body are comparatively smooth, the oblique ridges becoming apparent only towards the posterior margin; a reference to the figures will, however, give a better idea of the variations in the general aspect of the scale-sculpture than any amount of description.

The pectoral fin is rather small, its length being hardly more than half that of the head; the principal rays are unarticulated till towards their terminations. The ventrals are small and delicate, and not well exhibited in any of the specimens. The dorsal fin commences only very slightly in front of the anal, the two fins being thus placed nearly opposite each other; they are very similar in shape and structure, being moderate in size, acuminate, concavely cut out behind, and composed of delicate rays which dichotomise towards their extremities, are distantly articulated, and have their brilliantly ganoid joints marked usually by a single sharp longitudinal furrow, though even this is sometimes wanting save near the origin of the fin. Between the anal fin and the commencement of the lower lobe of the caudal, is an interval fully equal to the length of the base of the former. The caudal is also moderate in size, deeply bifurcated, and with a well-developed body-prolongation along the upper lobe; its rays partake of the same general appearances as those of the dorsal and anal, though their articulations are a little closer, and their surfaces usually quite smooth. Delicate fulcra are observable on the anterior margins of all the fins.

Geological Position and Localities.—This is by far the most common fish in the beds of Glencartholm, Eskdale, belonging to the Calciferous Sandstone Series. I have also identified with it (under the name of *Rh. elegantulus*) an imperfect specimen collected by the Geological Survey of Scotland in the Calciferous Sandstone beds near Gullane in East Lothian.

The original types are in the Collection of the Geological Survey of Scotland, but the specimen figured in this work (Pl. XXX, fig. 1) belongs to the Royal Scottish Museum.

B. Variety *elegantulus*,[1] Traquair. Plate XXX, figs. 7—11.

Description.—Length $2\frac{1}{2}$ to $2\frac{3}{4}$ inches, elegantly fusiform, general proportions as in

[1] In the explanation to Pl. XXX *Rhadinichthys elegantulus* has been inadvertently entered as a distinct species, instead of as a variety of *Rh. canobiensis*.

the foregoing, but the cranial roof-bones ornamented with closely set ridges, which are proportionately somewhat coarser and more contorted in their arrangement; in one very perfect specimen, in which the head-bones are beautifully exhibited (Pl. XXX, figs. 7, 8), the maxilla is destitute of tuberculation along its inferior margin. The scales are but faintly marked, those on the sides (fig. 10) and belly, as well as those towards the tail (fig. 11), being nearly smooth; their posterior margins display a few denticulations—four to five on the largest flank-scales, diminishing to two or three in those further back. The scales on the nape of the neck (fig. 9) are, as in the typical form, strongly striated. The most remarkable feature in this form is, however, the very small development of the low narrow ventral scales which are so conspicuous in the preceding. Such scales are, indeed, distinguishable along the ventral margin between the pectoral and anal fins, but on the other hand, on the abdominal region as many as eight scales may be counted down from the lateral line without any prominent change of form taking place.

Geological Position and Locality.—Rare in the Calciferous Sandstone Series at Glencartholm, Eskdale. The specimen here figured is in the Collection of the Geological Survey of Scotland.

C. Variety *delicatulus*, Traquair. Plate XXX, figs. 12—15.

Description.—Length from $1\frac{1}{2}$ to $3\frac{1}{4}$ inches; shape and general proportions as in the typical form.

The bones of the head and shoulder-girdle (fig. 13) are externally sculptured with delicate ridges, which, although they follow the same general pattern as in the typical form, show less tendency to contortion and interruption, and except along the dentary margin of the maxilla, are nowhere seen to break up into tubercles. The scales (figs. 14, 15) are proportionately thinner, and those of the front part of the body have their upper and lower margins rather straighter and more parallel with the long axis of the body, but the same arrangement of low narrow scales is seen along the belly. The vertical grooves along the anterior margin of the sculptured area of the scales are almost lost, nearly the whole surface being covered with minute sharp ridges and furrows, which, with the exception of one or two which run parallel with, and close to, the inferior margin, are directed rather diagonally across the scale, ending on the denticulations of the hinder border; sometimes two of these ridges terminate on one denticulation. Finally, this delicate ornament is in most cases continued back to the scales of the tail-pedicle itself. The fins are similar in position, shape, and structure to those of the typical form, but comparing specimens of the same size, their rays seem to be rather more delicate and more distinctly articulated.

Geological Position and Locality.—Rare in the Glencartholm fish-beds belonging to the Calciferous Sandstone Series. The specimen figured is in the Collection of the Geological Survey of Scotland.

General Observations.—Rhadinichthys canobiensis belongs to the "*carinatus*" group, but is evidently specifically distinct; the question is as to whether *elegantulus* and *delicatulus* should have the rank of species or of varieties. I have done my best with this question and consider my solution of it to be the best, or at least the most convenient that can be offered in the meanwhile, believing that in such cases it is better to be a "slumper" than a "splitter."

As regards *elegantulus*, it differs mainly from the typical form in the much smaller development of the low narrow scales in the ventral region, a distinction which I can hardly consider to be necessarily specific. Nor do I think it exactly safe to maintain *delicatulus* as a "species" on account of the slight difference in the sculpture of the scales.

4. Rhadinichthys monensis, *Egerton*, sp. Plate XXXI, figs. 3—6.

Palæoniscus monensis, *Egerton*. Quart. Journ. Geol. Soc., vol. vi, 1850, p. 5, pl. i, fig. 3.
Rhadinichthys monensis, *Traquair*. Proc. Roy. Phys. Soc. Edinb., vol. iv, 1878, p. 241.
— — *J. Ward*. Trans. N. Staffs. Inst. Mining Engin., vol. x, 1890, p. 175.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 467.
— — *E. D. Wellburn*. Geol. Mag. (4), vol. vii, 1900, pp. 260–263, and Proc. Yorks. Geol. and Polyt. Soc., vol. xiv, 1901, pp. 168, 174.

Description.—Only the detached scales were known to Sir Philip Egerton, the founder of the species, which, according to the state of knowledge at the time, he referred to the genus *Palæoniscus*. His brief description may here be quoted in full:

"*Palæoniscus monensis* Egerton, Pl. I, fig. 3. Lord Enniskillen found the specimens from which this species is named in the shale brought out of a coal-pit in the Isle of Anglesea, near the Holyhead Road a few miles from the Menai Bridge. They are single scales which belonged to a larger fish than *P. Egertoni* and differ in external characters from those of that species. The surface is traversed by regular parallel grooves, the ridges between these terminating in cusps at the posterior margin. In addition to these a series of fine lines is distinctly seen bordering two sides of the scale, apparently indicating the annual increment."

The sculpture of the scales, however, leads us at once to think of *Rhadinichthys* as the genus to which the fish that bore these scales belonged, and this position is established by the remains of the species which have turned up since Sir Philip Egerton wrote the above-quoted words.

The materials which I have examined, besides the type scales in the British Museum, are:

An imperfect fish which was in the collection of the late Dr. J. R. S. Hunter, of Braidwood, Lanarkshire.[1]

Some specimens of disjointed remains in the collection of the Geological Survey of Scotland.

An imperfect fish (Pl. XXXI, fig. 3) and some scales, three of which are represented in the same plate (figs. 4—6). These belong to the Royal Scottish Museum.

The scales of the flank are nearly equilateral, the articular spine is well marked, the covered area very narrow. The exposed surface is marked in the first place by a band of fine grooves passing closely along the anterior and inferior margins, the remaining and greater part of the area being occupied by more or less prominent ridges, which run backwards in a direction nearly parallel with the upper and lower margins and end on sharp denticulations of the posterior border. The usual number of these transverse ridges and denticulations seems to be four or five, but in the scale represented in Pl. XXXI, fig. 4, which apparently belongs to the same species, no less than nine may be counted. The scales on the belly are, as usual, low and narrow; posteriorly they also get smaller and their distinctive sculpture less strongly marked. The pectoral fin is moderate in size; its principal rays are unarticulated till towards their terminations; the ventral fins I have not seen. The median fins are exhibited in the specimen represented in Pl. XXXI, fig. 3. The dorsal and anal fins are in this example nearly opposite each other, but it is the anal which apparently commences a little in front of the dorsal; this, however, I attribute to *post-mortem* deformation, as the scales are considerably jumbled and as the two fins are seen in the position normal to the genus in a specimen figured by Wellburn. Only the larger rays are seen and these are broken off before dichotomisation; the articulations of the rays are distant, and the joints smooth or with one longitudinal furrow. The caudal fin shows the shape of the upper lobe pretty well, but the rays of the lower one are broken up; their articulations are distant.

A specimen in the collection of the Geological Survey of Scotland shows, lying together with a heap of the characteristic scales, the impression of a portion of the cranial buckler, and from this impression it is evident that its surface was sculptured with tolerably coarse ridges, passing here and there into tubercles. The position of the orbit is clearly shown, below which is found the left maxilla seen from its inner surface, together with the impression of the outer surface of the mandible. The oral margin of the maxilla is set with conical teeth, small indeed in the specimen, but large enough considering the small size of the jaw. The mandible is slender and tapering, sculptured with a few comparatively coarse ridges, which, as usual, pass forwards and also obliquely upwards, meeting the dental margin at very acute angles; its teeth are not exhibited. Lastly, behind the mandible are several confused bony rays, the remains of the pectoral

[1] No doubt lost in the fire which destroyed the Kilmarnock Museum on November 26th, 1909.

fin; these are clearly unjointed and show that, as is characteristic of the genus *Rhadinichthys*, the principal rays of this fin were unarticulated till towards their terminations.

The ordinary length of this species seems to have been from 3 to $3\frac{1}{2}$ inches.

Mr. E. D. Wellburn has, in his paper in the 'Geological Magazine' for June, 1900, given a description of remains of this species, likewise fragmentary, from the Coal Measures of Yorkshire, in which the details given above are corroborated. The text-figure which accompanies his remarks, and to which I have already alluded, shows a small fish wanting both head and caudal fin, but showing the dorsal, the anal, and some remains of the ventral. In this specimen the dorsal fin is seen to be placed nearly opposite the anal, though commencing slightly in front of it. Concerning the scales Mr. Wellburn also makes the following remarks, which I take the liberty of quoting: "In different individuals the scale-sculpture shows very considerable differences as regards the strength and prominence of the scale-markings, the sculpture being much more pronounced in the case of some individuals than in others, where the scales seem almost smooth. Another point of interest is, that in the young fish the ventral scales do not appear to be so low and narrow as they are in the more adult fish."

Observations.—We must await the discovery of more perfect specimens before a complete description of this species can be given. Meanwhile it is certain that its generic position is in *Rhadinichthys*, and that among the species reckoned to that genus it comes nearest to *Rh. carinatus* and *Rh. canobiensis*. In fact its scale-sculpture bears an obvious resemblance to that exhibited by the usual type of flank-scale in the last-named species (see Pl. XXX, fig. 2)—only the prominent transverse ridges are, in *monensis*, nearly horizontal and only very slightly oblique in their direction (Pl. XXXI, figs. 4, 5).

Geological Position and Localities.—The remains of *Rhadinichthys monensis*, though unfortunately mostly in a fragmentary condition, are pretty widely distributed in the Coal Measures or Upper Carboniferous Rocks of Great Britain. The following localities are recorded:

North Wales: The original scales, now in the British Museum, were found by the late Earl of Enniskillen in the Island of Anglesea.

Staffordshire: Deep Mine Ironstone, Longton, and Woodhill Coal Shale, Park Hill Colliery, Cheadle (J. Ward).

Yorkshire: The following are given by Mr. E. D. Wellburn: In the Lower Coal Measures: Halifax Soft-bed Coal, Shibden; Halifax Hard-bed Coal, Queensbury; Better-bed Coal, Low Moor and Wyke; Black-bed Coal, Low Moor; Cannel Coal, near Low Moor; Crow Coal, near Leeds. In the Middle Coal Measures: Cannel Coal, Tingley; Haigh Moor Coal, Castleford; Barnsley Thick Coal, Barnsley.

Lanarkshire, collected by the Geological Survey of Scotland; Newarthill, Royal Scottish Museum.

5. Rhadinichthys Macconochii, *Traquair*. Plate XXIX, figs. 7—11.

Rhadinichthys Macconochii, *Traquair*. Trans. Roy. Soc. Edinb., vol. xxx, 1881, p. 30, pl. ii, figs. 12—16.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 464.

Specific Characters.—Cranial roof-bones tuberculated; the ridges on the mandible so frequently interrupted as to cause the ornament to assume nearly as much of a tuberculated as of a striated character; scales not denticulated posteriorly; dorsal fin situated nearly exactly opposite the anal.

Description.—Length from 3 to $3\frac{3}{4}$ inches; shape elegantly fusiform; the length of the head contained a little more than four times in the total, and equal to the depth of the body midway between the pectoral and ventral fins.

The cranial roof-bones are ornamented with a close, comparatively coarse and frequently confluent tuberculation; the orbit is, as usual, anteriorly placed, and the ethmoid forms a projection over the mouth. The suspensorium is very oblique and the gape correspondingly extensive. The maxilla is of the usual form, its broad portion being ornamented with closely set ridges which run parallel with its superior and posterior margins; the beautifully tapering mandible is marked externally with ridges which pass from behind forwards in a slightly radiating manner, but which are also so frequently interrupted as to cause the ornament to assume nearly as much of a tuberculated as of a striated aspect. The operculum is of moderate size, rather broader below than above; the suboperculum is rather large; both of the plates are ornamented with prominent and proportionally coarse rugæ, which follow mostly the lines of growth.

The bones of the shoulder-girdle present nothing peculiar in form and arrangement, and are sculptured externally with ridges similar to those on the opercular bones.

The scales are of medium size, rhomboidal, as usual, diminishing in size dorsally, ventrally, and posteriorly; they are low and narrow on the belly from the throat to the anal fin, while those of the front part of the lateral line are proportionally higher than the others. The scales of the middle line of the back are small, until just in front of the dorsal fin, where a few of comparatively large size and imbricating arrangement are found. In one specimen forty-five oblique dorso-ventral bands of scales may be counted from the shoulder-girdle to the commencement of the lower lobe of the caudal fin. The scale-ornament (Pl. XXIX, figs. 8—11) is sharpest on the scales above the lateral line, where it consists first of a few sharp grooves parallel with the anterior margin and tending below to turn round along the inferior one, the rest of the area being occupied by two or three slightly prominent ridges passing somewhat obliquely towards the posterior margin, before reaching which they usually stop short—a marked feature in this species being that on no part of the body do the scales appear to be denticulated

posteriorly. Towards the tail (fig. 10) the vertical furrows become imperceptible or reduced to a single one. Below the lateral line the scale-ornament is for the most part less marked, though similar in character, but towards the tail-pedicle little or no difference is seen above and below.

The pectoral fin is scarcely more than half the length of the head; its principal rays are unarticulated till towards their terminations. The ventral (see fig. 7) is very small, and situated a little behind the middle point between the pectorals and the anal. The dorsal is placed far back, being nearly exactly opposite the anal; both of these fins are similar in appearance, being moderate in size, triangular, acuminate, and slightly cut out behind; their rays are of medium coarseness, smooth, dichotomising towards their extremities, and distantly articulated. The caudal is well developed, heterocercal, deeply cleft, the rays similar in appearance to those of the dorsal and anal; in the lower lobe dichotomising towards their extremities, in the upper towards the middle. Well-developed fulcra are seen along the fin-margins.

Observations.—The position of the above-described species in the genus *Rhadinichthys* is indicated by the structure of the pectoral fin, by the shape of the scales, and the nature of their sculpture, even although the scales are not denticulated posteriorly, and although the dorsal fin is placed still further back than is usual in *Rhadinichthys*, its position being hardly, if at all, in advance of the anal. These two last-mentioned characters ally it to *Cycloptychius*, but the peculiar form of scale with the postero-inferior angle rounded off, which constitutes one of the main diagnostic marks of that genus, is here absent. Its main specific characters—the tuberculation of the cranial shield, the peculiar sculpture of the mandible, and the non-denticulation of the posterior margins of the scales, taken with its size and proportions—are so exceedingly well marked that it may be at once identified even from fragments.

This species is named after Mr. Arthur Macconochie, of the Geological Survey of Scotland, to whose work in the field is due the discovery of the rich deposits of new fishes and Crustacea in the Lower Carboniferous Rocks of Eskdale and Liddisdale.

Geological Position and Localities.—Not uncommon in the fish-beds of Calciferous Sandstone age near Glencartholm, Eskdale, Dumfriesshire. The type specimen is in the Collection of the Geological Survey of Scotland, but the example here figured (Pl. XXIX, fig. 7) belongs to the Royal Scottish Museum.

My friend, Prof. Maurice Leriche, of Lille, has noticed and figured[1] a small scale from the Upper Carboniferous (Westphalian) of Fresnes in the north of France, which he refers to *Rhadinichthys Macconochii*. Certainly his figure shows an astonishing resemblance to a flank-scale of the species under consideration with the postero-inferior angle broken off.

[1] 'Ann. Soc. Géol. Nord,' vol. xxxvii (1908), p. 270, text-fig. 1, pl. vii, fig. 3.

6. Rhadinichthys Wardi, *Ward, sp.* Plate XXXI, figs. 1, 2.

Palæoniscus Wardi, *J. Young.* Proc. Nat. Hist. Soc. Glasgow, vol. ii, pt. i, 1875, p. 66 (name only).
— — *J. Ward.* Proc. N. Staffs. Nat. Field Club, 1875, p. 239.
Rhadinichthys Wardi, *Traquair.* Quart. Journ. Geol. Soc., vol. xxxiii, 1877, p. 559, and Proc. Roy. Phys. Soc. Edinb., vol. iv, 1878, p. 239.
— — *J. Ward.* Trans. N. Staffs. Inst. Mining Engineers, vol. x, 1890, p. 175, pl. vi, fig. 10.
— — *A. S. Woodward.* Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 467.

Specific Characters.—Attaining a length of about 5 inches; scales denticulated posteriorly; free surface ornamented with ridges which tend constantly to break up into isolated tubercles.

Description.—The following description is taken from a suite of specimens collected by the late Mr. J. Ward, of Longton, and now in the British Museum. The most perfect of those specimens (Pl. XXXI, fig. 1) measures $4\frac{1}{2}$ inches, but the extremity of the tail being broken off, its original length may be estimated at $\frac{1}{4}$ inch more. The form of the body is rather slender, and gradually tapering from the shoulder to the tail-pedicle; the greatest depth of the body is contained about five times, and the length of the head a little less than four times in the length of the body up to the bifurcation of the caudal fin. The head appears large for the slender form of the fish. The orbit is, as usual, very anteriorly placed, the suspensorium very oblique, the gape enormous, the jaws powerful and armed with formidable teeth in two sets. Of these, the laniaries, or teeth of the inner series, are slender, conical and incurved, $\frac{1}{24}$ to $\frac{1}{30}$ inch in length in a mandible of $\frac{3}{4}$ inch, set at intervals of considerably less than their own length, while external to them is a series of closely set teeth of very small size. The opercular bones are not well preserved but appear to be of moderate size; eight branchiostegal rays may be counted in one specimen, but they are clearly not all shown. All the external bones of the head, as well as of the shoulder girdle, are sculptured with fine, sharp, flexuous ridges. The pectoral fins are of considerable expanse, each consisting of about twenty-five rays, of which the principal ones are unarticulated for more than two-thirds of their length. The ventral is seen in one specimen; it appears small and delicate though its extremity is not preserved; its rays are slender with distant articulations. The dorsal fin rises far back, being placed nearly opposite the anal and commencing only a little in front of it; it, the dorsal, is acuminate in shape, and is rather concave behind; the anal is not so well preserved, but appears similar in form to the dorsal. It is hardly possible to ascertain the number of rays in either, but in both they are slender, bifurcated towards their terminations, and divided by rather distant articulations. The caudal

is large and deeply bifurcated, but in no case is it well preserved; its rays are likewise slender and distantly jointed, the articulations, however, becoming closer in the shorter rays of the upper lobe; the caudal body-prolongation is slender. The scales are of moderate size; their anterior covered area is very narrow; the keel of the under surface and the articular spine, or peg, well marked. The exposed surface (fig. 2) is ornamented with exceedingly well-marked elevated ridges, which pass across the scale from before backwards with a slight downward obliquity, and end in denticulations of the posterior margin. These ridges tend constantly to become broken up into isolated tubercles, or conversely, the ornament may be described as consisting of raised tubercles tending constantly to a linear arrangement and to coalescence into ridges.

Observations.—*Rhadinichthys Wardi* may be distinguished from all the other species of the genus by its peculiar ridged and tuberculated scale-ornament, co-existent with denticulation of the posterior border.

It was named by the late Professor Young, of Glasgow, but first described by Mr. Ward himself, which accounts for the somewhat unusual circumstance of an author's name standing as authority for a species which has been named after him.

Geological Position and Localities.—An Upper Carboniferous fish. Not uncommon in the Coal Measures of North Staffordshire, especially in the "Ash Coal" shale at Fenton and Longton (Ward Collection, British Museum), in the Coal Measures of the neighbourhood of Manchester (collected by the late Mr. John Plant), and in the Lanarkshire Coalfield (Collection of the Geological Survey of Scotland).

7. Rhadinichthys brevis, *Traquair*. Plate XXXI, figs. 7—10.

Rhadinichthys brevis, *Traquair*. Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 440.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 463.
— — *Traquair*. Geol. Mag. [4], vol. viii, 1901, p. 111.
— — *Traquair*. Trans. Roy. Soc. Edinb., vol. xlvi, pt. i, no. 4, p. 109, pl. ii, figs. 3—5.

Specific Characters.—Attaining a length of about 4 inches; form stout and short; distance between the anal fin and the commencement of the caudal less than the length of the base of the anal; cranial roof-bones ornamented with contorted and rather flattened rugæ; flank-scales with a few feebly marked, oblique ridges, and with five or six denticulations on the posterior border.

Description.—The length of the specimen from Wardie represented in fig. 7 is $3\frac{1}{2}$ inches; the extremity of the caudal fin is, however, not preserved. Another specimen, more badly preserved posteriorly, must have been a little longer, judging from the size of the head and body. The head is elegantly shaped with bluntly pointed muzzle.

The opercular bones are rather small, the jaws pretty stout; the dentition is not visible. The bones of the cranial roof are sculptured with contorted and rather flattened rugæ; those of the face are ornamented with sharp and closely set, wavy ridges, which, on the operculum, pass obliquely downwards and backwards over its surface. The scales are of moderate, one might almost say small, dimensions, and though, of course, gradually diminishing towards the tail, those on the flanks are not marked by any very special excess in size. The flank-scales are nearly equilateral; the posterior margin of each shows five or six prominent oblique denticulations; the outer surface shows a few feebly marked, nearly obsolete ridges passing obliquely backwards and a little downwards, and not very regularly placed. Immediately behind the clavicle and above the origin of the pectoral fin the sculpture is, however, more strongly pronounced, the ridges being finer, sharper, and closer together, but posteriorly the scales soon become nearly smooth. The paired fins are rather small; the principal rays of the pectoral are clearly seen to be unarticulated till towards their terminations; the ventrals are situated midway between the pectorals and the commencement of the anal; their rays are delicate and distantly jointed. The dorsal and anal fins are large and situated nearly opposite each other, the former commencing slightly in front of the latter, as is usual in the genus. Both have the same form, being high and acuminate in front and concavely cut out behind; their rays are rather coarser than those of the ventrals and their articulations distant. The distance between the commencement of the lower lobe of the caudal and the termination of the base of the anal, is less than the length of the base of the latter. The caudal fin is usually imperfectly preserved, as in figs. 7 and 9; however, it is pretty well seen in fig. 8—the prolongation of the body-axis in the upper lobe being delicate, the rays slender and with delicate articulations.

Geological Position and Localities.—The type specimens are from Wardie Beach, near Edinburgh, but I cannot separate from them fishes more or less entire which have been collected at Pitcorthy, in Fifeshire, and Gullane, in East Lothian—two examples from the last-named locality being here figured (Pl. XXXI, figs. 8 and 9). The species is as yet only known from the Calciferous Sandstone Series.

8. Rhadinichthys hibernicus, *Traquair*, sp. nov. Plate XXXII, figs. 1, 2.

Specific Characters.—Attaining a length of between 6 and 7 inches; length of head contained four and two-thirds times in the total; fins small; dorsal situated almost exactly opposite anal; scales sculptured with fine, closely set ridges, branching, intercalated and wavy, but on the whole following a transverse direction parallel with the superior and inferior margins, and apparently ending in fine denticulations of the posterior margin.

Description.—The length of the unique specimen is $6\frac{4}{5}$ inches; the length of the head, which is about equal to the depth of the body, is contained four and two-thirds in the

total. The shape is elegantly fusiform, though the back appears somewhat unusually arched, but is evidently the result of *post-mortem* distortion. The head is obliquely crushed so that the posterior boundary of the opercular bone is not clearly defined, but the branchiostegal plates of both sides are obscurely indicated, as is likewise the cleft of the mouth, which shows traces of conical incurved teeth. More than this cannot be said regarding the cranial structure, except that the external surfaces of the bone show everywhere traces of a fine tuberculo-striate ornamentation.

The scales appear small for the size of the fish, those of the flank being not much more than $\frac{1}{10}$ inch in height, and rather less in breadth; they become very small on the tail-pedicle, where they are succeeded by the acutely lozenge-shaped ones of the caudal body prolongation. The surface of the scales (fig. 2) is covered with closely set, delicate, yet well-marked ridges or striæ—wavy, sub-parallel, branching and intercalated—whose direction is mainly across the scale from before backwards and parallel with the upper and lower margins. I rather think that these ridges end in fine denticulations of the hinder margin, but as the state of preservation is not good I cannot feel sure. It is also to be noted that the scales on the belly are considerably lower and narrower in form than those on the sides of the body.

The fins are rather small. The impression of the right pectoral is seen just behind the head. It is $\frac{9}{10}$ inch in length, narrow and pointed; distinct fulcra are seen along its anterior border; its rays are slender and apparently unarticulated for a considerable distance, but owing to the state of preservation of the specimen it is difficult to say how far.

The dorsal fin is situated far back, commencing opposite a point 4 inches from the front of the head; the length of its base is a trifle less than $\frac{7}{10}$ inch, that of its longest rays slightly over $\frac{1}{2}$ inch. Its rays are slender, closely set, their articulations not distinctly marked; fulcra are not observable along the anterior border.

The anal fin is larger than the dorsal; although its apex is not perfect, its anterior rays reach a length of $\frac{7}{10}$ inch; the full extent of its base is also not seen. Fulcra are not visible along the anterior margin, but that does not necessarily imply their absence in the species.

The caudal is also small for the size of the fish, and is preserved up to the extremity of the upper lobe, though only a portion of the lower one remains. The length of the base of the caudal fin from the commencement of the lower lobe to the tip of the upper one is $1\frac{3}{10}$ inch, which is very short for a Palæoniscid fish of the size. The rays of this fin are slender and have their divisions longer than broad, but, owing to the anterior margin not being preserved, no fulcra can be seen.

Observations.—This unique specimen, representing a new and beautiful species of *Rhadinichthys*, is contained in the British Museum, and for the privilege of naming and describing it I am indebted to the kindness of Dr. Smith Woodward, F.R.S., Keeper of the Geological Department. Of its novelty there can be no doubt when we take into

account the sculpture of the scales, the smallness of the fins, and the general proportions of the fish.

Geological Position and Locality.—From the Coal Measures, Jarrow Colliery, Co. Kilkenny, Ireland.

9. Rhadinichthys macrodon, *Traquair*. Plate XXXII, figs. 3—5.

Rhadinichthys macrodon, *Traquair*. Geol. Mag. [3], vol. iii, 1886, p. 441.

— — *J. Ward*. Trans. N. Staffs. Inst. Mining Engin., vol. x, 1890, p. 177.

— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 469.

— — *E. D. Wellburn*. Proc. Yorks. Geol. and Polyt. Soc., 1907, pp. 168 and 174.

Specific Characters.—Laniary teeth of unusually large size; flank-scales covered with delicate ridges and furrows, which run nearly parallel with the upper and lower margins of the scale, though they tend to turn upwards anteriorly; posterior margin sharply and prominently denticulated.

Description.—The specimen (Pl. XXXII, fig. 3) upon which this species is founded measures 5 inches in length, but it is broken off just behind the commencement of the caudal fin, as indicated by the dorsal ridge-scales; the length of the head is $1\frac{1}{4}$ inches, and the depth of the body nowhere exceeds 1 inch. Consequently the general aspect is that of a fish of slender form, but the specimen cannot be relied on as showing the original shape, as the scales are broken up and confused, and the fin-rays almost entirely wanting. The head exhibits the typical Palæoniscid structure—the suspensorium being very oblique, the gape wide, and the usual arrangement of opercular and branchiostegal plates being shown; the bones are, however, seen almost exclusively from their internal surfaces. Both jaws are armed with stout, conical, incurved teeth of unusually large proportional size, those of the maxilla measuring $\frac{1}{12}$ to $\frac{1}{10}$ inch in length; the small external teeth are not visible. The scales are of comparatively large size, those of the anterior part of the flank (fig. 5) having their exposed areas covered with delicate ridges and furrows, which are nearly parallel with the upper and lower margins of the scale, though they tend to turn upwards anteriorly; the posterior margin is sharply and prominently denticulated. As we proceed backwards the scales lose the sharpness of their ornament, and become nearly smooth towards the tail, though the caudal V-scales remain prominently striated. The origin of the pectoral fin is present (fig. 3), though not well shown, and here the principal rays seem unarticulated. A few broken-up ray-joints mark the position of the dorsal and anal fins, the former occurring 3 inches, the latter $3\frac{3}{4}$ inches behind the front of the head.

Observations.—The condition of the specimen renders its generic determination a matter of great uncertainty, but I am inclined to place it in *Rhadinichthys* for the following reasons: (1) the apparent elongation of the body, on which, however, little weight can be placed; (2) the resemblance of the scales, in shape and ornament, to those of the typical *Rh. ornatissimus* (Agass.); (3) the appearance of the broken rays of the root of the pectoral fin. Specifically I have named it as distinct, as I am not acquainted with any other form in which teeth of such large proportional size occur with scales of similar conformation and markings.

Geological Position and Localities.—Upper Carboniferous. The only specimen which I have seen is the type, here figured, which was collected by the late Mr. Ward from the Knowles Ironstone Shale, Longton, Staffordshire, and is now in the British Museum. Mr. Wellburn also mentions it as occurring in the "Better Bed" Coal, Low Moor, Yorkshire.

10. Rhadinichthys Hancocki, *Atthey*, sp. Plate XXXIII, figs. 1, 2.

Palæoniscus Hancocki,		*T. Atthey.*	Ann. Mag. Nat. Hist. [4], vol. xv, 1875, p. 311, and in Nat. Hist. Trans. Northumb. and Durham, vol. v, 1877, p. 228.
Rhadinichthys	—	*Woodward and Sherborn.*	Cat. Brit. Foss. Vertebrata, 1890, p. 175.
—	—	*A. S. Woodward.*	Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 469.
—	—	*E. D. Wellburn.*	Proc. Yorks. Geol. and Polyt. Soc., 1907, pp. 168 and 174.

Specific Characters.—At least two rows of specially high-shaped scales on the flank; external markings of scales apparently consisting of oblique rugæ; ornament of cranial roof-bones consisting of comparatively coarse flattened tubercles which are also irregular in form.

Description.—Unfortunately, owing to the indifferent state of preservation of the specimens, no very satisfactory description can be given of the species, nor can satisfactory drawings be made of its details.

It is a comparatively slender fish attaining a length of from 3 to 4 inches, and a depth of about $\frac{1}{2}$ inch more or less, but here it must be taken into account that all the specimens are to a certain extent deformed. In the least-distorted specimen the length of the head is contained about six times in the total.

The cranial roof-bones and those of the jaws are covered with proportionately coarse, flattened tubercles of irregular form; the gape is wide, the mandible of medium stoutness. Mr. Atthey described the teeth as being "very minute and of two sizes, larger and smaller, and closely set in the jaws," but I have not been able to see them in any of the

specimens which I have examined. The operculum (Text-fig. 7) is broad, the suboperculum trapezoidal, the anterior margin being only half as long as the posterior. Mr. Atthey described the operculum as "smooth," but the fact is that only the internal surface of it as well as of the suboperculum is seen.

The scales are hard to describe, being much broken, and for the most part only seen from their internal surfaces. It is to be noted, first, that there are along the flank two rows of scales which are much higher than the others. Mr. Atthey described their external surfaces as "smooth," but I am of opinion that, as in the case of the opercular plates, only their *inner* surfaces are exhibited. Traces of the outer surfaces are, however, occasionally seen, and these display an undoubted rugose ornament. The posterior border of these scales is finely denticulated. The other body-scales are much smaller, except a long ridge-scale, which, in one specimen, is seen in front of the dorsal fin.

The pectoral fin (see fig. 1) is small, and contains about ten rays, which are unarticulated for the greater part of their length; very oblique fulcra may also be distinguished along its anterior margin.

The ventrals (see fig. 2) are situated midway between the pectoral and the anal;

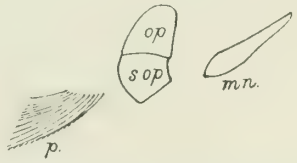


Fig. 7.—Sketch to show the form of the opercular bones in *Rhadinichthys Hancocki* (Atthey); *op.*, operculum; *s.op.*, suboperculum; *mn.*, mandible; *p.*, pectoral fin.

they are also small, but their rays, which are smooth with distant articulations, cannot be counted.

In no specimen are the dorsal and anal completely preserved, but their remains are seen in the specimen represented in fig. 2. There the dorsal is seen to be placed nearly opposite the anal, and in the case of both fins the rays are rather disturbed and not all of them seen; their surfaces are smooth, and their transverse articulations distant.

The caudal fin is seen badly in two of the specimens; it is heterocercal, inequilobate, the prolongation of the body-axis in the upper lobe being very weak.

Observations.—An undoubted *Rhadinichthys*, the present species is distinguished from all the other known members of the genus by the longitudinal bands of high-shaped scales along the flank.

Geological Position and Localities.—From the roof-shale of the Low Main Coal Seam at Newsham, near Newcastle-on-Tyne. The type specimens, collected and described by the late Mr. Thomas Atthey, are in the Museum of the Natural History Society, Newcastle, and I have to acknowledge my indebtedness to the Council of the Society, as well as to Mr. Leonard Gill, Curator of the Museum, for the loan of these specimens for the purposes of the present work.

The species has also been recorded by Mr. E. D. Wellburn from the "Better Bed" Coal, Low Moor, Yorkshire.

11. Rhadinichthys lævis, *Traquair*, sp. nov. Plate XXXIII, figs. 3—6.

Specific Characters.—Scales smooth, except immediately behind the shoulder-girdle; posterior margin of the scales mostly free from denticulation; maxilla and dentary bone of mandible finely tuberculated, except a narrow band along the lower margin of the latter, which is longitudinally striated.

Description.—The length of the specimen as it lies is $4\frac{1}{2}$ inches—the original length, if we allow for deficiency of snout and caudal extremity, would not be under 5 inches. The form of the fish (Pl. XXXIII, fig. 3) is rather deeply fusiform, the greatest depth of the body being contained a trifle over four times in the estimated total length. The head is shown in impression only; the snout is deficient, and what is seen of the imprint of the posterior part of the cranial roof shows that it had externally a tuberculated ornament. The impression of the opercular bones is not visible, but those of the maxilla and mandible (fig. 4) stand out clearly, and show, first, that the maxilla was finely and closely tuberculated; and second, that the dentary of the mandible was similarly ornamented, excepting a narrow band along the inferior margin, which was finely and longitudinally striated.

The scales are of moderate size, rhombic, and, so far as can be seen, for the most part free from denticulation of the hinder margin. Some few denticulations are, however, occasionally seen on the flank-scales, as in the one represented in fig. 5. All over the body they are smooth, excepting only a very limited space immediately behind the shoulder-girdle, where the impressions give evidence that here the surface was ornamented with well-defined ridges passing obliquely downwards and backwards. Fig. 6 represents one of the scales near the caudal extremity of the body.

Traces of the pectoral fin are seen immediately behind the jaws, and, so far as can be seen, they conform to the *Rhadinichthys*-type in being unarticulated till towards their terminations. The ventrals are not shown, and only a few joints of the anal fin-rays remain. The dorsal is situated far back, opposite such traces of the anal as are present; it appears very small and with very delicate rays, which are also smooth and distantly articulated. The caudal is deeply cleft and inequilobate, the prolongation of the body-axis along the upper lobe being very well developed.

Observations.—When I first saw the above-described specimen I thought I had an example of *Rh. Macconochii* before me, but a careful examination of it convinced me that it belonged to a distinct and previously unrecognised species. It differs from *Rh. Macconochii* in the following particulars:

First, in the greater prevalence of a tuberculated ornament on the external head-bones.

Secondly, in the general smoothness of the scales and absence of the sculpture characteristic of *Rh. Macconochii.*

Thirdly, in the presence of some amount of denticulation of the posterior borders of the flank-scales.

There is no other known species with which *Rh. lævis* can be confounded.

Geological Position and Locality.—From the Calciferous Sandstone Series at Tarras Foot, Eskdale (Collection of Geological Survey of Scotland).

12. Rhadinichthys Grossarti, *Traquair*. Plate XXXIII, figs. 7, 8.

Rhadinichthys Grossarti, *Traquair*. Proc. Roy. Phys. Soc. Edinb., vol. iv, 1878, p. 244.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 469.

Specific Characters.—Attaining a probable length of somewhat over 2 inches; form slender; fins few-rayed; rays with distant articulations; scales marked externally by from four to six sharply defined straight ridges, passing from before backwards with a slight obliquity, and terminating posteriorly in denticulations of the hinder margin.

Description.—The material for the description of this little fish is as follows:

(1) The type specimen collected by the late Mr. Grossart, surgeon, Salsburgh, Lanarkshire, and now in the Royal Scottish Museum.

(2) Two specimens from Crossford, Lanarkshire, collected by Mr. R. Dunlop, who presented one of them to the above-named institution.

(3) Fragmentary specimens in the Collection of the Geological Survey of Scotland.

The type specimen (Pl. XXXIII, fig. 7) measures $1\frac{1}{2}$ inches as it lies, but it is deficient in the head and anterior part of the body. The shape is slender, its depth at the ventral fin being not quite $\frac{1}{4}$ inch, from which it tapers to a very delicate tail-pedicle. The pectoral fin is not seen; the ventral is small, and consists of a few delicate and rather disturbed rays. The dorsal commences very slightly in front of the anal, and consists of fourteen or fifteen rays, but in the anal I count only ten. Between the latter and the lower lobe of the caudal there is a considerable interval, equalling nearly three-fifths of an inch. All these fins are very delicate, with slender distantly articulated rays; minute fulcra are observable on the anterior margin of the dorsal in the specimen under description and of the anal in another; the caudal body-prolongation is very slender and attenuated. The scales are moderate, may, indeed, be called large in proportion to the small size of the fish. They are more strongly marked than in *Rh. monensis*, their ornament (fig. 8) consisting of from four to six sharply defined straight ridges passing from before backwards, with a slight obliquity over nearly the whole exposed surface, and terminating in denticulations of the posterior margin;

in some cases feeble traces of the delicate vertical grooves seen in *Rh. monensis* are visible just in front of the commencement of the longitudinal ridges.

In the specimen from Crossford, presented by Mr. Dunlop to the Royal Scottish Museum, the head is present, but not in good enough preservation for description. The length of the entire specimen is 2 inches, but there must be some shortening up between the shoulder and the dorsal fin, otherwise the length of the head would be contained only a little over three times in the total. Some remains of the pectoral fin are seen just where the head joins the body, consisting of rays which are distinctly seen to be unjointed for a considerable distance. The dorsal fin seems here to commence slightly more in front of the anal than in the type, but this is due to distortion; both of these fins are badly preserved.

Observations.—Distinguished from the doubtful form *Rh. angustulus*, which resembles it in scale-sculpture, by its long, narrow tail-pedicle. It is also a larger fish.

Geological Position and Localities.—Coal Measures of Lanarkshire: Shotts; Crossford.

13. Rhadinichthys Planti, *Traquair*. Plate XXXIII, figs. 9, 10.

Rhadinichthys planti, *Traquair*. Geol. Mag. (3), vol. iii, 1886, p. 441.
— — *J. Ward*. Trans. N. Staffs. Inst. Mining Engin., vol. x, 1890, p. 177, pl. iv, fig. 6.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 469.
— — *E. D. Wellburn*. Proc. Yorks. Geol. and Polyt. Soc., vol. xiv, 1901, pp. 168 and 174.

Specific Characters.—A small species attaining a length of over 2 inches; form slender; ethmoidal region of skull forming a considerable prominence over the mouth; dorsal fin situated exactly opposite the anal; cranial roof-bones ornamented with comparatively coarse flattened ridges.

Description.—The most perfect specimen I have seen (Pl. XXXIII, fig. 9) measures $2\frac{1}{8}$ inches in length by $\frac{7}{20}$ in greatest depth; its shape is, therefore, elegant and slender. The head measures $\frac{9}{12}$ inch in length, and is contained nearly five times in the total; the dorsal fin $1\frac{1}{4}$ inches behind the tip of the snout, and the lower lobe of the caudal $1\frac{3}{4}$ inches behind the same point, the anal being exactly opposite the dorsal. The pectorals are not exhibited in any specimen I have seen, but traces of a ventral are seen in one case midway between the anal and the shoulder-girdle.

The head (Text-fig. 8), shows a peculiarly large development of snout forming a considerable bluntly pointed prominence over the mouth. The cranial roof-bones are ornamented with incised furrows, producing a comparatively coarse flattened ridging

between them. The suspensorium is oblique; the operculum is broad, but with its inferior margin sloping obliquely upwards so as to make an acute angle with the anterior, and an obtuse angle with the posterior margin. Correspondingly, the superior margin of the suboperculum slopes very obliquely upwards and backwards, its anterior margin being short and the posterior one long and rounded. The upper limb of the preoperculum is broad and triangular, the lower one narrow. I see no markings on these opercular bones save a few concentric striæ. The maxilla is of the ordinary Palæoniscoid shape, but in none of the specimens are its markings clearly shown. The mandible (Pl. XXXIII, fig. 10) is comparatively short, and is ornamented with prominent ridges which run obliquely forward so as to touch the upper or dentary margin at very acute angles. I have not observed the teeth.

The scales are small, rhombic, and with the usual Palæoniscoid mode of articulation. It is extremely difficult to make out accurately the character of their outer surfaces, which seem to be ornamented with excessively minute and faintly marked ridges and furrows, bearing obliquely in a direction downwards and backwards.

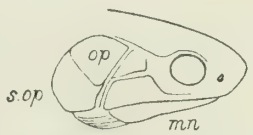


FIG. 8.—Sketch of the bones of the side of the head of *Rhadinichthys Planti*, Traq. Enlarged by one-half, and slightly restored, from a specimen from Burnley in the British Museum, No. P. 7989. *op.* operculum; *s. op.* suboperculum; *mn.* mandible.

Observations.—In my first notice of this strange little Palæoniscid I placed it only provisionally under *Rhadinichthys*, and stated that probably a new genus would ultimately have to be instituted for its reception. Certainly, so far as I am aware, we do not as yet know the conformation of the rays of the pectoral fin, and the peculiar large development of the ethmoidal region of the cranium is not found in any other species of the genus, yet it seems to me now to be better to allow it to remain, as originally placed, in the genus *Rhadinichthys*. As regards the relative position of the dorsal and anal fins, they are also situated exactly opposite each other in *Rhadinichthys Macconochii*, and I should not think of removing it from its genus on that account.

Geological Position and Localities.—Coal Measures. The best specimens I have seen, including the one figured, were collected by the late Mr. John Plant, of the Royal Museum, Salford, who obtained them at Collyhurst, near Manchester; these are now in the British Museum (Natural History). Others, less perfect, were found by the late Mr. Ward in the Deep Mine Ironstone Shale, Longton, and are now also preserved in the National Museum. The species has been also collected at Burnley, Lancashire, by the late Mr. George Wild, and Mr. E. D. Wellburn has recorded it, though with a query, from the "Better Bed" Coal, Low Moor, Yorkshire.

14. Rhadinichthys ferox, *Traquair*. Plate XXXIV, figs. 1, 2.

Rhadinichthys ferox, *Traquair*. Proc. Roy. Soc. Edinb., vol. ix, 1877, p. 435.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 469.

Specific Characters.—Scales of moderate size, and ornamented with a prominent ridged pattern; the ridges on the lower and anterior part of the exposed surface being mainly parallel with the inferior and anterior borders of the scale, while those on the posterior and upper part pass obliquely downwards and backwards to the hinder margin, which is denticulated. Cranial plates striated; teeth strong. Fins large; the distance between the end of the base of the anal and the commencement of the caudal somewhat extended.

Description.—The only entire specimen, which is represented in Pl. XXXIV, fig. 1, has undergone a twist about the middle of the body, and shows, moreover, only a portion of the caudal fin, so that it is difficult to estimate its original length. As it is, it measures $5\frac{3}{4}$ inches in length, but it is quite evident that when alive it must have been considerably longer.

The head equals $1\frac{3}{4}$ inches in length, and shows superiorly a cast of the greater part of the inner surface of the cranial buckler, with the lines of demarcation between the parietal, frontal, squamosal and post-frontal bones. The opercular bones are not seen, but a portion of the maxilla and the greater part of the mandible are exhibited, the latter bearing sharp conical teeth of different sizes, those externally placed being very small, while one large laniary $\frac{1}{10}$ inch in length is conspicuous. In another specimen the impressions are seen of the parietal, squamosal, opercular, preopercular and supra-clavicular bones, and of the posterior part of the maxilla, these impressions clearly showing that the external sculpture of the bones in question was of a highly ornate character, consisting of sharply-defined, flexuous, branching, anastomosing, and interrupted ridges, tending to pass into tubercles at the inner margin of each parietal.

The scales are of moderate size on the flanks, becoming rather small posteriorly, while on the belly they are low and narrow. Over the whole body their outer surfaces are highly ornate, the ornamentation consisting of fine, sharply defined ridges forming a pattern, which is usually, as it were, divided by a diagonal passing from the antero-superior to the postero-inferior angle of the scale. On the antero-inferior half of the surface the ridges run parallel with the anterior and inferior margins, impinging posteriorly on the diagonal, while on the postero-superior half they pass obliquely downwards and backwards, mostly parallel with the diagonal, and ending in the denticulations of the hinder margin; in many cases they are interrupted before reaching that margin, and replaced by other shorter ones springing up between them. In some

cases, also, a few of the ridges of the upper half near the antero-superior angle of the scale likewise impinge upon the diagonal, consequently meeting those of the lower half at acute angles.

The pectoral fin is well shown in the specimen figured (Pl. XXXIV, fig. 1), in which it measures rather more than an inch in length. It is of considerable expanse, and consists of at least thirty rays, of which the stronger ones, namely the first fifteen counting from the lateral margin, are unarticulated till towards their terminations, where bifurcation sets in. The ventrals are not shown. A portion of the dorsal is seen arising opposite the anterior part of the anal; its rays are rather delicate with distant articulations. The anal is seen to be of large size and of triangular acuminate form. Its base is $1\frac{1}{10}$ inch in extent and its long anterior rays seem to have exceeded that length, though they are cut off at the apex; the fin is, moreover, badly preserved and its anterior margin somewhat distorted and injured. The origin of the lower lobe of the caudal is also shown, consisting of exceedingly closely set, deeply imbricating rays, of which I count at least forty up to where they begin to pass into those of the upper lobe, but here the tail is unfortunately truncated by the edge of the nodule. It is likewise to be noted that the distance between the end of the base of the anal fin and the commencement of the caudal is, as in several other species of the genus, somewhat extended.

Observations.—This species is most distinctly marked off from all those we have considered as yet, by the sculpture of the scales and the large size of the fins. The next species, *Rh. formosus*, displays, however, a somewhat similar scale-ornament, but the distance between the anal fin and the commencement of the lower lobe of the caudal is proportionately shorter.

Geological Position and Locality.—In ironstone nodules from the shales of Wardie, near Edinburgh, belonging to the Calciferous Sandstone Series; rare.

15. Rhadinichthys formosus, *Traquair*. Plate XXXIV, figs. 3—6.

Rhadinichthys formosus, *Traquair*. Summary of Progress, Geol. Surv. for 1903 (1904), p. 122.

— — *Traquair*. Trans. Roy. Soc. Edinb., vol. xlvi, pt. i, No. 4, 1907, p. 109, pl. i, fig. 6, pl. ii, figs. 6—8.

Specific Characters.—Attaining an estimated length of about $5\frac{1}{2}$ inches; shape somewhat deeply fusiform; scales highly ornate, the sculpture of a flank-scale consisting of sharp ridges, which, on the postero-superior part of the scale, run obliquely downwards and backwards across the surface, while on the antero-inferior part they run parallel with the anterior and inferior margins: posterior margin denticulated;

distance between the anal fin and the commencement of the caudal rather less than the length of the base of the former.

Description.—The original specimen of this form is represented in Pl. XXXIV, fig. 3; unfortunately it is not perfect, as nearly the whole of the upper and a great portion of the lower lobe of the caudal fin are lost. As it is, the length is $3\frac{3}{4}$ inches, but when entire the fish must have measured $4\frac{1}{2}$ inches. The length of the head is contained three and a half times in the distance from the tip of the snout to the commencement of the lower lobe of the caudal fin, and is equal to the greatest depth of the body between the dorsal fin and the occiput. The cranial roof-bones are marked with fine contorted and interrupted striæ, and a striated ornament characterises also the facial bones, namely, the maxillæ, mandible and branchiostegal rays. The dorsal fin is situated behind the arch of the back and more than twice the length of the head from the end of the snout; the anal commences a little further back; both fins are large, triangular-acuminate, with many slender rays which are distantly articulated, the joints being often marked with a delicate furrow close to and parallel with the posterior margin. The fulcra on both fins are very well marked. The caudal fin is, as already indicated, broken off near its commencement; indications both of pectoral and ventral rays are seen at their proper places, but the fins themselves cannot be described. The scales are moderate in size, those on the flank showing an ornament which resembles that of the last-described species as well as to some extent that of the scales of *Elonichthys pulcherrimus* of the Glencartholm beds, the exposed surface being covered with closely-set ridges, those on the postero-superior part passing obliquely downwards and backwards, while in the antero-inferior aspect they first pass, as fine striæ, downwards parallel with the anterior margin, and then, turning at an angle and becoming sharp and prominent, like those above, pass horizontally across the scale to the posterior border. On the hinder border of each scale these ridges end in delicate denticulations. As regards the scales posterior to the ventral fins, the ornament tends to become less pronounced and reduced to a set of grooves passing obliquely across the surface from front to back, but the scales along the origin of the anal fin, and also of the dorsal, as seen in the counterpart, are strongly ridged. All over the body the scales are singularly undisturbed, so that the proportions of the fish are accurately shown.

In fig. 6 is represented another specimen, which, according to its scale-ornamentation and other details, I identify specifically with the one described above. Its proportions seem, however, at first sight, rather different, the dorsal fin appearing relatively further forwards, the caudal disproportionately large, while the depth of the body at the shoulder is considerably greater than the apparent length of the head. But on a careful examination of the specimen it is evident that these appearances are due to distortion by "shortening up," the scales of the region behind the head being confused, so that the body at this place is, as it were, "telescoped." The specimen measures $4\frac{1}{2}$ inches in length, but I should add at least one more inch to express its original dimensions, so that

we have now before us a larger example than the previous one. I figure this specimen on account of the perfect caudal extremity which it displays. The fin is deeply cleft and inequilobate, the prolongation of the body-axis along the upper lobe being proportionately stronger than in the type specimen of the genus (*Rh. ornatissimus*).

Observations.—I have placed this species in *Rhadinichthys* owing to its resemblance in external form to *Rh. brevis*, although the condition of the pectoral fin cannot be ascertained. I have alluded to the certain amount of resemblance which the sculpture of the scales bears to that in *Rh. ferox*, but the greater proportional distance between the anal and caudal fins in the latter suffices to distinguish them.

Geological Position and Locality.—Collected by the Geological Survey of Scotland from shales belonging to the Calciferous Sandstone Series, exposed on the shore near Gullane, in East Lothian.

16. Rhadinichthys tuberculatus, *Traquair*. Plate XXXV, figs. 1—3.

Rhadinichthys tuberculatus, *Traquair*. Trans. Roy. Soc. Edinb., vol. xxx, 1881, p. 31, pl. iv, figs. 1—3.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 469.

Specific Characters.—Attaining an estimated length of over 8 inches; fins large; scales with a ridged tuberculate ornament, and not denticulated posteriorly; caudal body-prolongation largely developed.

Description.—The following description is taken from two specimens, one of which, belonging to the Geological Survey of Scotland, was figured in my paper quoted above; the other, figured in Pl. XXXV, fig. 1 of the present work, is in my own collection.

The length of the first specimen is 7 inches from the tip of the snout to the bifurcation of the caudal fin; the extremity of the upper lobe of the tail is not preserved, otherwise the length of the fish would probably be at least $8\frac{1}{2}$ inches. The length of the head is 2 inches, equalling the greatest depth of the body just in front of the ventral fins and being contained rather more than four times in the estimated total. The depth of the tail-pedicle is $\frac{3}{4}$ inch.

The head is much crushed and its bones badly preserved; its structure is, however, clearly seen to be typically Palæoniscoid with very oblique suspensorium, anteriorly placed orbit, wide gape and powerful jaws. The operculum seems somewhat long and narrow, the suboperculum square-shaped. No teeth are visible.

The bones of the head being almost everywhere seen only from their internal surfaces, their external ornamentation is but scantily exhibited. Evidences of a minutely tubercular sculpture, the tubercles being sometimes rounded, sometimes slightly elongated or confluent, are seen on the parietal and ethmoidal regions of the

cranial roof, as well as, in impression, on a small portion of the suboperculum. Towards the extremity of the mandible also a patch of the outer surface of the bone is seen, but here the ornamentation consists of closely set delicate, wavy ridges, running in a longitudinal direction.

The bones of the shoulder-girdle—supra-clavicular, clavicle, and infra-clavicular—are pretty well shown, the two latter from their internal aspects only. The outer surface of the supra-clavicular displays some traces of longitudinal striated sculpture.

The scales are rather small for the size of the fish, especially at the tail, towards which they rapidly diminish. In the flank-scales (Plate XXXV, fig. 2) the covered area is narrow; the sculptured one presents a few fine ridges and grooves along the anterior margin, the rest of the space being covered with small closely-set tubercles, sometimes rounded, sometimes elongated or confluent. Towards the tail (fig. 3) and also towards the dorsal and ventral margins the tubercles largely give way to a ridged ornamentation; the ridges running parallel with the anterior and inferior margins, sometimes also with the superior, while the postero-central portion of the area is occupied by tubercles which tend to become confluent into diagonal ridges, which are a little coarser as well as more wavy and irregular than the marginal ones already mentioned. Powerful longitudinally-ridged V-scales protect the upper margin of the caudal body-prolongation, which is of great strength, while the acutely lozenge-shaped scales which clothe its sides are of small size, arranged in many rows, and, so far as they are traceable, ornamented with sharp diagonal ridges.

On the attached surface of the body-scales the vertical keel is rather delicate, yet very distinctly defined, as is also the socket for the reception of the articular peg of the scale next below; and, as usual, the pegs and sockets disappear in the scales of the posterior part of the body. No denticulations are observable on the posterior margins of any of the scales.

The pectoral fin is $1\frac{1}{4}$ inches in length and has its principal rays unarticulated for the greater part of their length. The origin of the ventral is situated $1\frac{5}{16}$ inches behind that of the pectoral; the fin itself is not in good preservation, its rays being much broken up, so that its shape and size are lost. The dorsal fin is situated nearly opposite the anal, arising opposite a point 4 inches back from the tip of the snout; the anal commences only a little behind the dorsal and extends correspondingly further back. Both of these fins are large, each measuring about an inch in length at the base, and the same in height anteriorly, although the larger rays do not seem to be preserved up to their extremities. They are also very similar in shape, being triangular and acuminate; their numerous and rather delicate rays have their transverse articulations somewhat distant, so that the joints are rather longer than broad; no sculpture is visible. The caudal is incompletely preserved, the extremities of both lobes being wanting, but enough is seen to show that it was powerfully developed, deeply cleft, and having a body-prolongation of great strength along the upper lobe; the rays

are similar in character to those of the dorsal and anal. Well-developed fulcra are seen in connection with the anterior margins of the fins wherever these margins are preserved.

The specimen represented in Pl. XXXV, fig. 1 of the present work, gives, however, a better view of the fins than the above-described example. The head and anterior part of the body are crushed and shortened up—the head, indeed, being in a state of hopeless mash—but the right pectoral fin, with its rays unarticulated till towards their terminations, is rather well shown. The ventral is not seen, but the respective contours of the dorsal, anal, and caudal are clearly exhibited, as well as the great strength of the caudal body-prolongation.

Observations.—I have referred this beautiful Palæoniscid to *Rhadinichthys* on account of the structure of the pectoral and the relative position of the dorsal and anal fins, although the caudal body-prolongation is more powerfully developed than in the more typical members of the genus, such as *Rh. ornatissimus, Rh. carinatus*, etc. As regards its specific determination, the peculiar ridged, tubercular scale-ornament and non-denticulated scales, together with the largely developed caudal body-prolongation, are characters which collectively distinguish it from all other known species.

Geological Position and Locality.—From the fish-beds of Calciferous Sandstone age near Glencartholm, Eskdale.

17. Rhadinichthys fusiformis, *Traquair*. Plate XXXV, figs. 4—9.

Rhadinichthys (?) fusiformis, *Traquair*. Trans. Roy. Soc. Edinb., vol. xxx, 1881, p. 31, pl. iv, figs. 1—3.
— — *A. S. Woodward*. Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, p. 469.

Specific Characters.—Attaining a length of over 5 inches; shape fusiform; length of head equal to the greatest depth of the body and contained nearly $4\frac{1}{2}$ times in the total; dorsal fin placed far back so as to be nearly opposite the anal; distance between the anal fin and the commencement of the lower lobe of the caudal less than the length of the base of the anal; caudal body-prolongation well developed. For the sculpture of the scales, see under "Description."

Description.—The head is typically Palæoniscoid in structure, with oblique suspensorium, wide gape, ethmoidal prominence, and anteriorly-placed orbit. The cranial roof-bones are ornamented with closely set, irregularly contorted rugæ, which, frequently interrupted, pass at times into tubercles. The operculum is oblong, the suboperculum, as usual, short and quadrate; these plates are in all cases ill-preserved so that little can be said of their external sculpture, save that it seems to be of a striated character. The

PLATE XXXI.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

Fig.

1. *Rhadinichthys Wardi* (Ward); natural size. From a specimen in the Ward Collection, British Museum (Natural History), no. P. 7986. Ash Coal Shale, Longton, Staffordshire.
2. Flank-scale, magnified six diameters. Same horizon and locality.
3. *Rhadinichthys monensis* (Egerton); natural size; head and anterior part of body wanting. From the Virtuewell Coal Shale, Lower Coal Measures, Newarthill, Lanarkshire, and contained in the Royal Scottish Museum, Edinburgh.
4. Flank-scale of the same species, magnified six diameters, the articular peg being concealed by the matrix. Same horizon and locality. Royal Scottish Museum, Edinburgh.
5, 6. Scales of the same species, a little further back, and more towards the margins of the body in position. Same horizon and locality, and also preserved in the Royal Scottish Museum.
7. *Rhadinichthys brevis*, Traquair; natural size. From the Lower Carboniferous (Calciferous Sandstone Series) at Wardie, near Edinburgh. One of the type specimens in the Collection of the Author.
8. Another specimen of the same species; natural size. From shale belonging to the Calciferous Sandstone Series at Gullane, East Lothian. In the Collection of the Geological Survey of Scotland.
9. A third specimen of the same species from the same horizon and locality, also in the Collection of the Geological Survey of Scotland.
10. Scale from a Gullane specimen of the same species; magnified eight diameters.

Fig 7

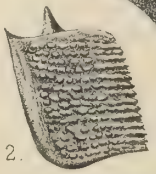


Fig 2. $\frac{6}{7}$

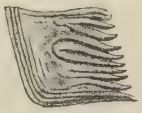


Fig. 4. $\frac{6}{7}$

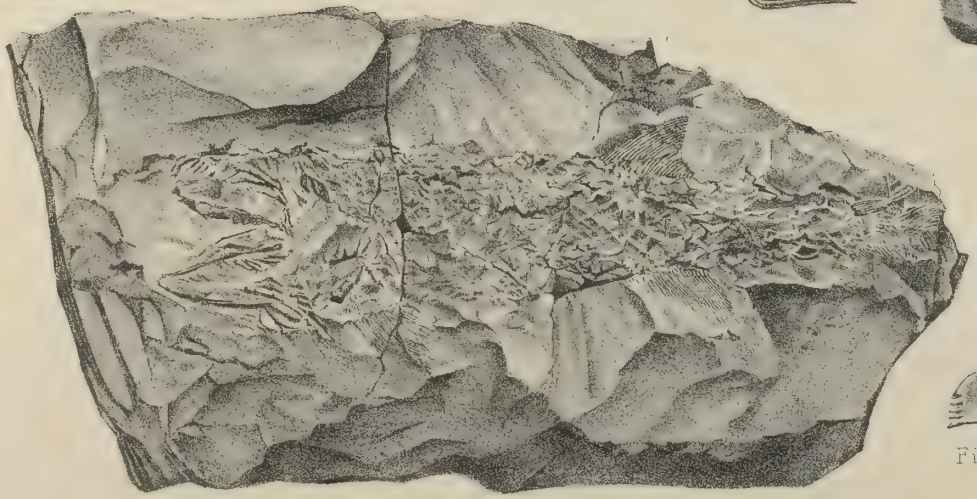


Fig. 1.

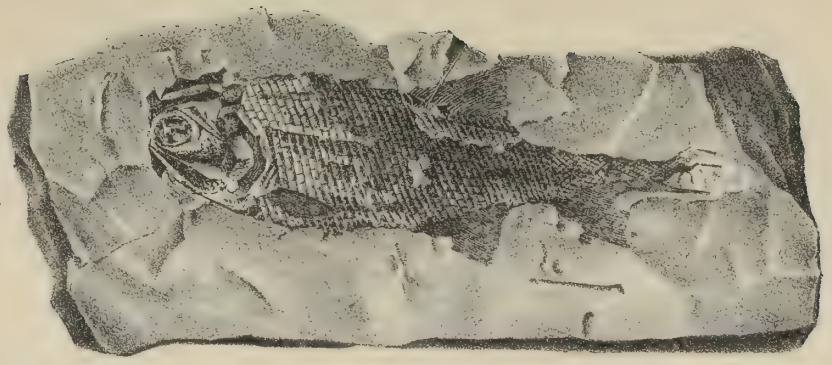


Fig 8.

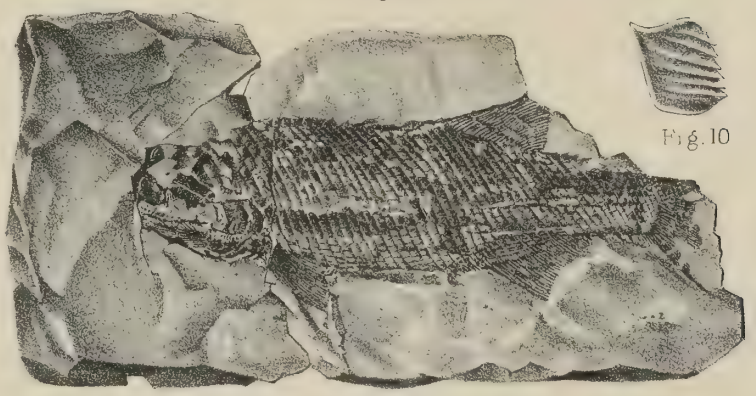
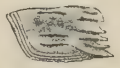


Fig. 10

Fig 9.



$\frac{6}{7}$

Fig. 5.

$\frac{6}{7}$

Fig 6.

Fig. 3.

Figs 1,2,4,5,6,10, Dr & Mrs Traquair.
Figs 3,7,8,9. J Green

J.Green in lap.

PLATE XXXII.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

Fig.

1. *Rhadinichthys hibernicus*, Traquair; natural size. From the Coal Measures, Jarrow Colliery, Co. Kilkenny, Ireland. In the British Museum (Natural History), no. P. 9603.
2. Scales from the same specimen, magnified five diameters.
3. *Rhadinichthys macrodon*, Traquair; natural size. From the Knowles Ironstone Shale, Longton, Staffordshire. In the Ward Collection, British Museum (Natural History), no. P. 7990.
4. Counterpart of the head of the same specimen, enlarged by one-half. Also in the British Museum (Natural History).
5. Flank-scale from the same specimen, magnified five diameters. The articular peg is not shown.

Fig. 1

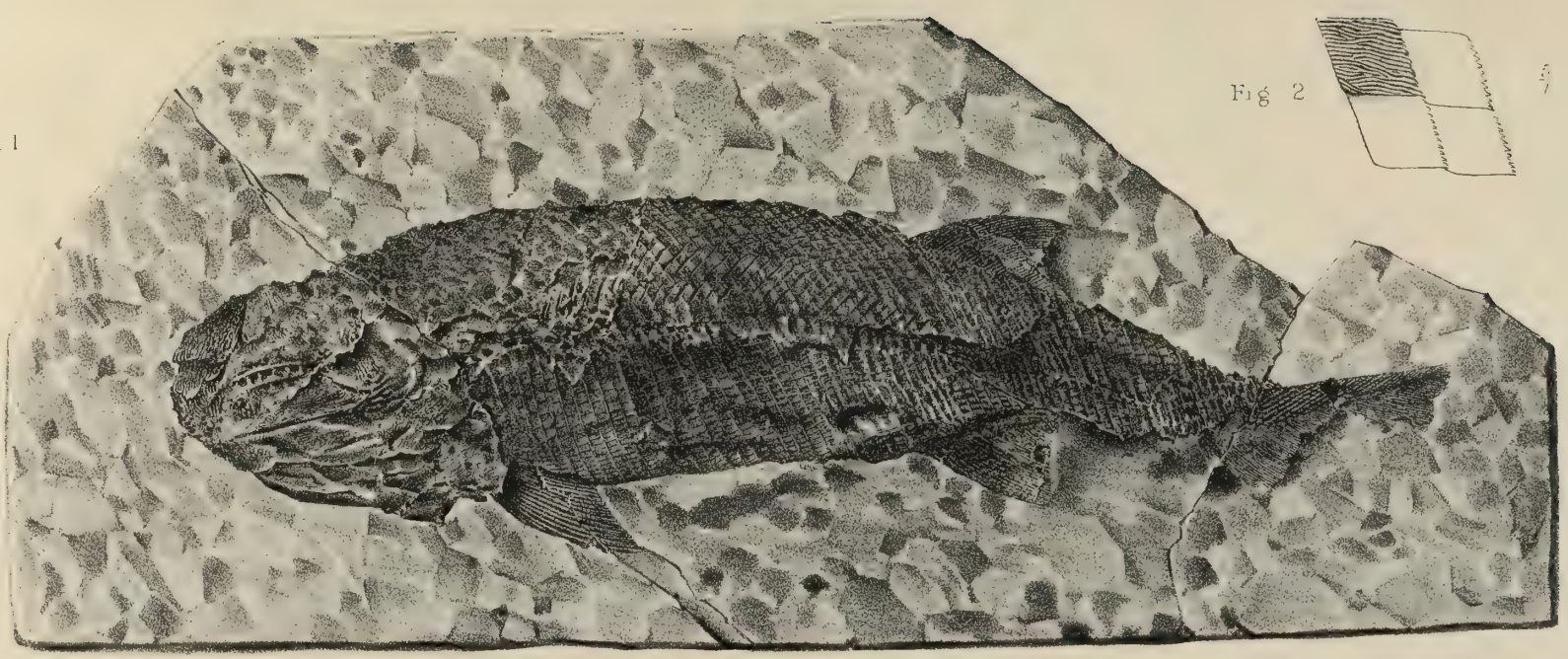
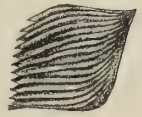


Fig. 2 $\frac{5}{7}$

Fig. 5. $\frac{5}{7}$



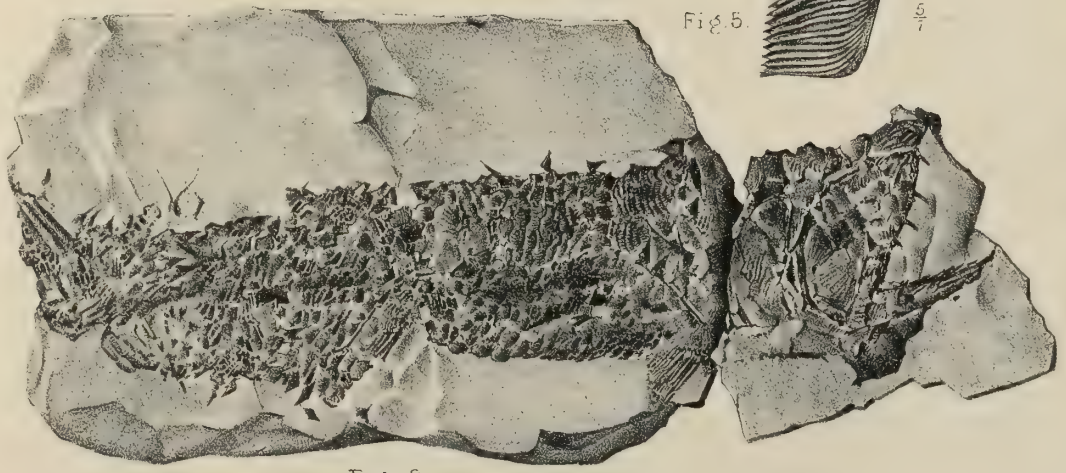


Fig. 3.

Fig. 4 $\frac{1}{2}$

Figs. 1, 3 & 4. J. Green.
Figs. 2 & 5. R.H. Traquair.

J. Green in lap.

PLATE XXXIII.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

Fig.

1. *Rhadinichthys Hancocki* (Atthey). Specimen showing the head and pectoral fin, but deficient at the caudal extremity. From the Low Main Coal Shale, Newsham, Northumberland. In the Atthey Collection, Museum of the Natural History Society, Newcastle-on-Tyne.
2. Another specimen, wanting the head and caudal fin, but showing the position of the ventral, dorsal, and anal. Also in the Atthey Collection, Museum of the Natural History Society, Newcastle-on-Tyne, and from the same horizon and locality.
3. *Rhadinichthys lævis*, Traquair. Natural size. From the Calciferous Sandstone Series, Tarras Foot, Eskdale, Dumfriesshire. In the Collection of the Geological Survey of Scotland.
4. Impression of the outer surface of the mandible and maxilla in the same specimen, enlarged by one-half.
5. Flank-scale from the same specimen, magnified five diameters.
6. Scale further back, same specimen, magnified five diameters.
7. *Rhadinichthys Grossarti*, Traquair. Natural size. From the Coal Measures of Salsburgh, Lanarkshire. In the Royal Scottish Museum, Edinburgh.
8. Flank-scale of the same species, magnified six diameters.
9. *Rhadinichthys Planti*, Traquair. Natural size. From the Coal Measures of Collyhurst, near Manchester. In the British Museum (Natural History), no. P. 8497.
10. Mandible (teeth not exhibited) of the same species, enlarged one and a half times. Deep Mine Ironstone Shale, Longton, Staffordshire. In the Royal Scottish Museum.

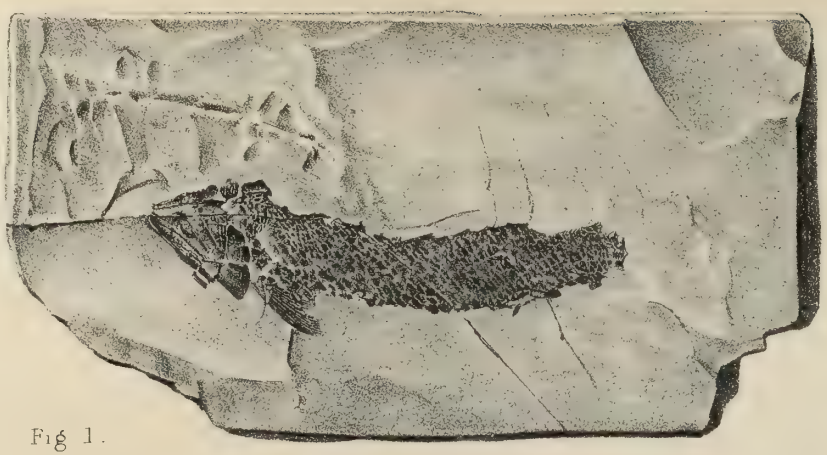


Fig. 1.

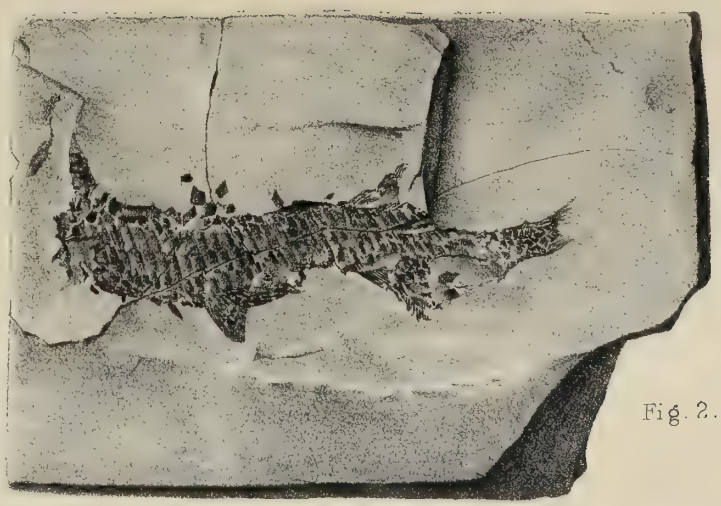


Fig. 2.

Fig. 7.

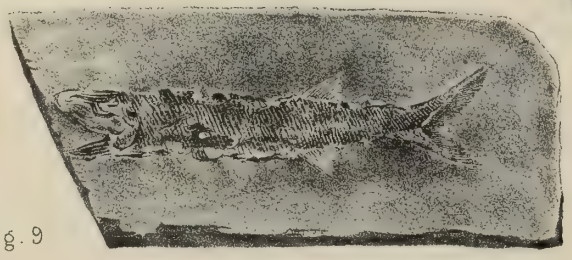


Fig. 9

Fig. 8.

Fig. 10.

Fig. 6.

Fig. 4.

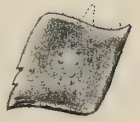


Fig. 5.

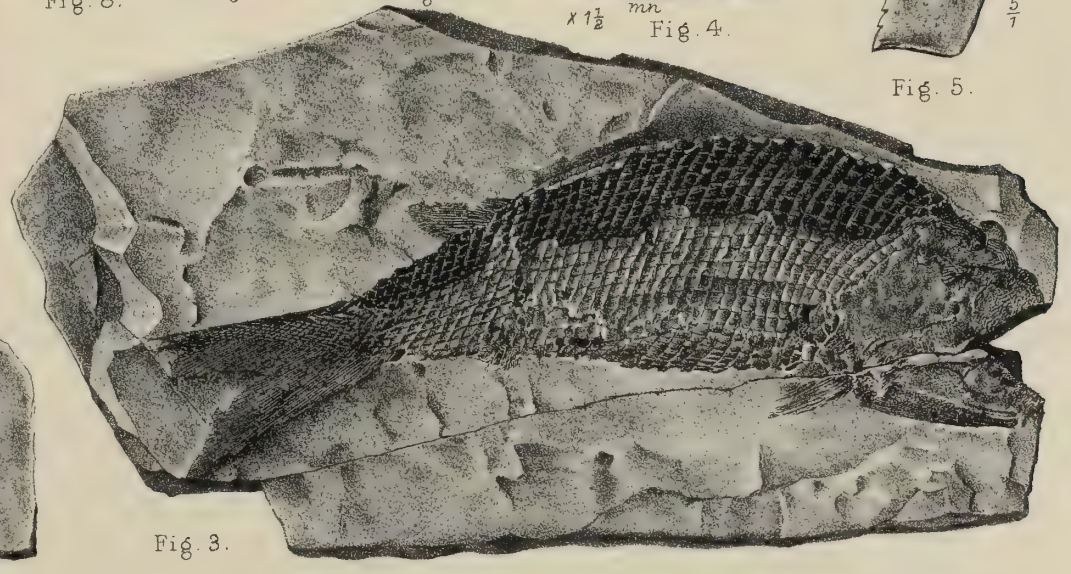


Fig. 3.

Figs. 1, 2, 3, 7. J. Green.
Figs. 4, 5, 6, 8, 9, 10, Dr & Mrs Traquair.

J. Green in lap.

PLATE XXXIV.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

Fig.

1. *Rhadinichthys ferox*, Traquair; natural size. From the Calciferous Sandstone Series at Wardie, near Edinburgh. Hugh Miller Collection, in the Royal Scottish Museum, Edinburgh.
2. Sculpture of scales, magnified six diameters.
3. *Rhadinichthys formosus*, Traquair; natural size. From the Calciferous Sandstone Series, sea shore near Gullane, East Lothian. Collection of the Geological Survey of Scotland.
4. Scale from the flank of the same specimen, magnified six diameters.
5. Scale from the caudal region of the same specimen, magnified six diameters.
6. Another specimen from the same locality; natural size. Distorted by "shortening up" of the anterior part of the body. Collection of the Geological Survey of Scotland.

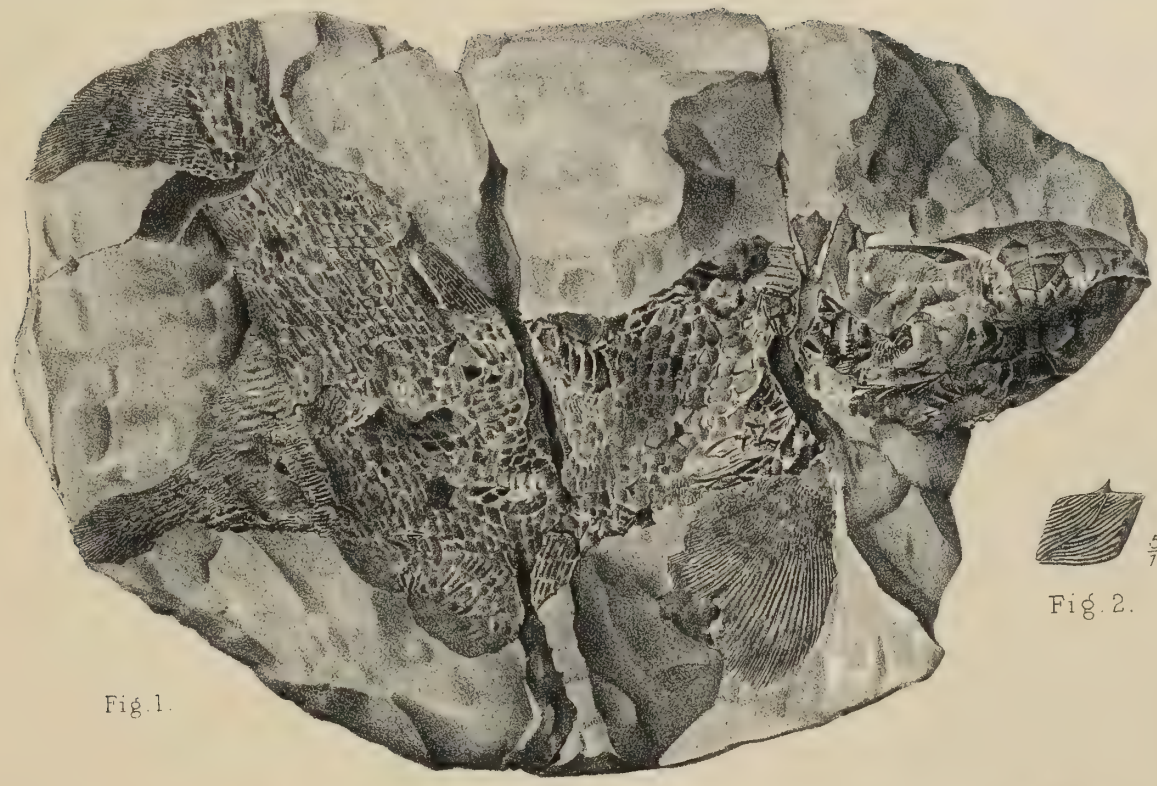


Fig. 1.

$\frac{5}{7}$

Fig. 2.

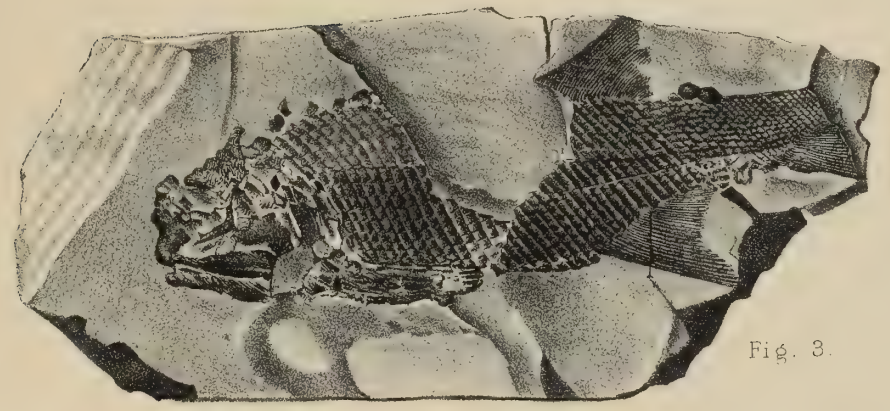
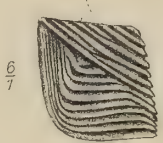


Fig. 3.

$\frac{6}{7}$

Fig. 5.



$\frac{6}{7}$

Fig. 4.

Fig. 6.

Figs 1, 3, 6, J. Green.
Figs. 2, 4, 5, R. H. Traquair.

J. Green in lap

PLATE XXXV.

(The cost of this plate has been defrayed by the Carnegie Trust for the Universities of Scotland.)

Fig.

1. *Rhadinichthys tuberculatus*, Traquair. Natural size. From the Calciferous Sandstone Series, Glencartholm, Eskdale, Dumfriesshire. In the Collection of the Author.
2. Flank-scale, magnified six diameters. From the type specimen in the Collection of the Geological Survey of Scotland. Same horizon and locality.
3. Scales towards the caudal extremity, magnified six diameters. From the same specimen.
4. *Rhadinichthys fusiformis*, Traquair. Natural size. Calciferous Sandstone Series, Glencartholm, Eskdale. In the Collection of the Author.
5. Another specimen from the same horizon and locality. Also in the Collection of the Author.
6. Flank-scale, magnified six diameters. From one of the type specimens in the Collection of the Geological Survey of Scotland.
7. Flank-scale from another specimen, magnified six diameters. From the same horizon and locality. In the Collection of the Geological Survey of Scotland.
8. Narrow ventral scales, magnified six diameters. Geological Survey of Scotland.
9. Scales towards the tail, magnified six diameters. Geological Survey of Scotland.

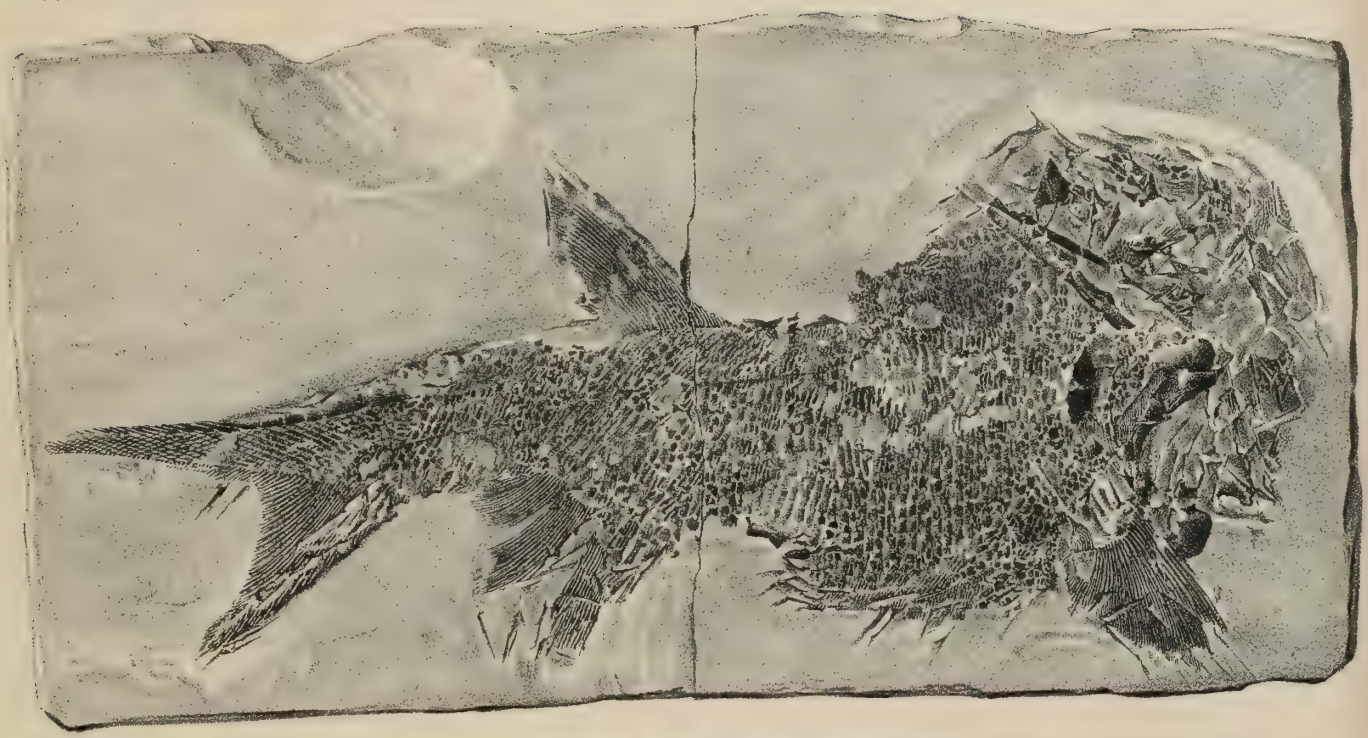


Fig. 1.

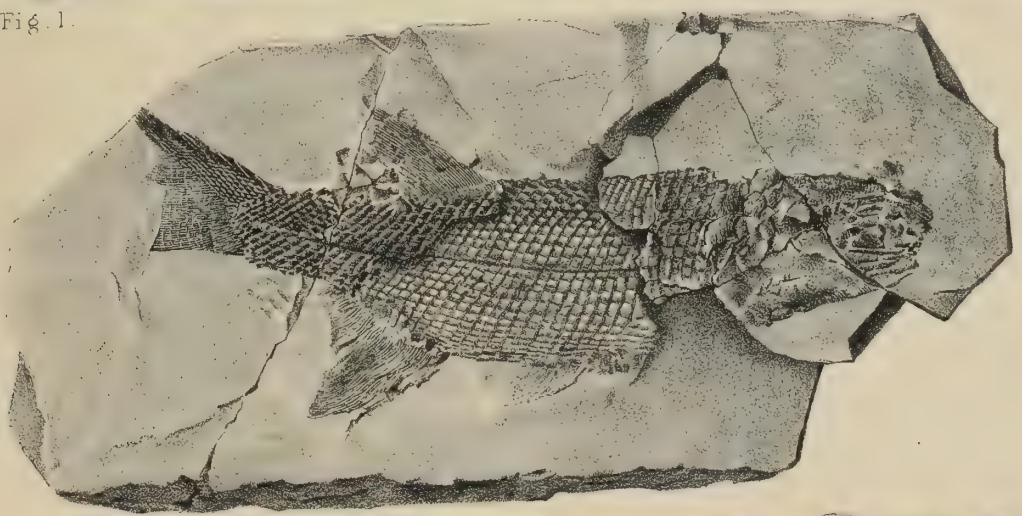


Fig. 4.

$\frac{6}{7}$

Fig. 3.

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Fig. 2.

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Fig. 6.

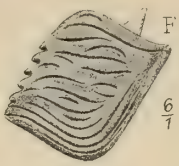

Fig. 7.

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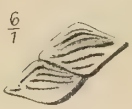

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Fig. 9.

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Fig. 8.

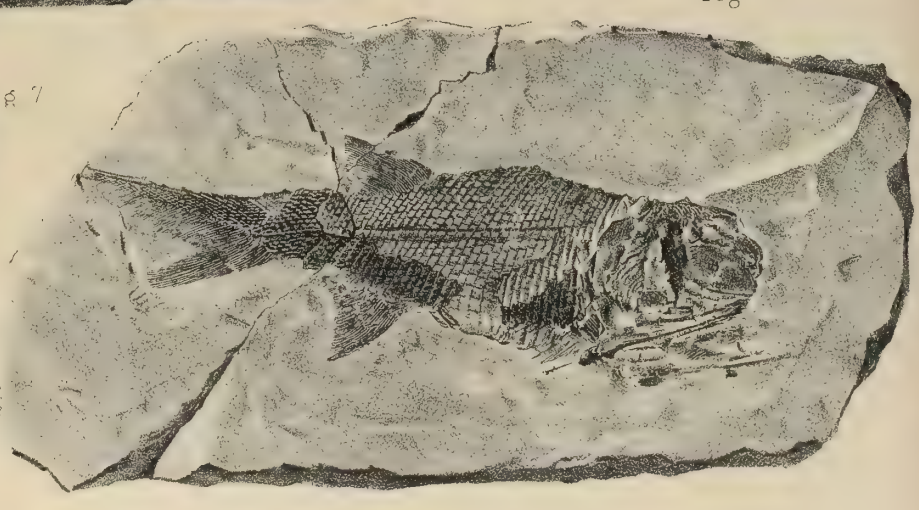

Fig. 5.

Figs. 1, 4, 5, J. Green.
Figs. 2, 3, 6, 7, 8, 9, R. H. Traquair.

J. Green in lap.

Palæontographical Society, 1910.

THE FOSSIL FISHES OF THE ENGLISH CHALK.

BY

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the inner aspect; beak-tritor composed of a series of laminæ, the other tritors consisting of numerous tubules; median tritor divided (except when abraded) into two small and widely-separated parts, of which the anterior is placed on the edge of the symphysis, and the posterior behind the anterior outer tritor. Palatine plate with very large tritors, the two inner being broad, and the posterior of these tending to overlap the narrow outer tritor. Vomerine plate with a concave or grooved symphysial surface; the anterior tritor much larger than the others.

Description of Specimens.—Though found most abundantly in the Cambridge Greensand, the dental plates of this species appear to occur at all horizons in the Chalk. Only one specimen, however, from the Chalk near Lewes, has hitherto been discovered to show all the dental plates of one mouth in a satisfactory state of preservation. This has already been described and figured by E. T. Newton, *loc. cit.*, whose drawings of the left palatine and left mandibular dental plates are copied in Text-figs. 54, 55. In the mandibular plate the relative prominence of the beak varies considerably in different specimens, and the appearance of the inner or median tritor depends on the extent to which it is uncovered. In the left mandibular plate, shown in Pl. XL, figs. 4—4 *b*, for example, the beak is much longer than in the original of Text-fig. 55; while its median tritor (*e.*) is exposed only in two narrow patches and appears to be completely subdivided into two parts. The anterior outer tritor of the same specimen (fig. 4 *a*, *c.*) is also relatively small and well separated from the outer oral margin. To the same individual as the mandibular plate belongs the vomerine plate shown in Pl. XL, figs. 5—5 *b*. This, again, is remarkable for the prominence of the beak, and suggests that the vomerine dental plates named *Edaphodon gigas* by Egerton (Quart. Journ. Geol. Soc., vol. iii, 1847, p. 352, and Newton, *op. cit.*, p. 17, pl. v, figs. 1, 2) really represent a variety of *E. sedgwicki*. Its beak-tritor is relatively large; the next four tritors are small; and then the sixth tritor of the series is of considerable size.

Horizons and Localities.—Senonian zones: Norwich. Turonian zones: neighbourhood of Lewes, Sussex. Zone of *Schloenbachia varians*: Dover, Kent. Also Gault, Red Chalk, Cambridge Greensand, and Lower Greensand.

2. **Edaphodon mantelli** (Buckland). Plate XLI, fig. 1.

1835–36. *Chimæra mantellii*, W. Buckland, Proc. Geol. Soc., vol. ii, p. 206, and Phil. Mag. [3], vol. viii, p. 5.

1843. *Ischyodus mantelli*, P. M. G. Egerton, Proc. Geol. Soc., vol. iv, p. 156.

1843. *Chimæra* (*Psittacodon*) *mantellii*, L. Agassiz, Poiss. Foss., vol. iii, p. 348, pl. xl *a*, figs. 1, 2.

1847. *Edaphodon mantellii*, P. M. G. Egerton, Quart. Journ. Geol. Soc., vol. iii, p. 352.

1850. *Edaphodon mantelli*, F. Dixon, Geol. Sussex, p. 203, pl. xxxiv, figs. 6, 7.

1878. *Edaphodon mantellii*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv.), p. 14, pl. iv, figs. 1—9.

1891. *Edaphodon mantelli*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. ii, p. 75.

Type.—Pair of imperfect mandibular dental plates; British Museum.

Specific Characters.—Dental plates much resembling those of *E. sedgwicki*, but more slender and not attaining so large a size.

Description of Specimens.—The mandibular dental plates of the type specimen display both the outer and the inner aspects, and have already been described and figured by Agassiz and Newton, *loc. cit.* An exactly similar plate, only crushed in the lower half of the symphysial region, is shown in Pl. XLI, figs. 1, 1*a*. Its prominent beak and very wide symphysial facette are well shown, and the arrangement of the tritors is also seen. The median tritor (*e.*) is completely exposed, and observed to be continuous to the symphysis. The palatine dental plate is associated with a mandibular pair from Lewes, described by E. T. Newton, *loc. cit.* It differs from that of *E. sedgwicki* in being more slender, with the tritors longer and narrower.

A right mandibular dental plate from Glynde in the Willett Collection, Brighton Museum (No. 143), exhibits the median tritor subdivided into several portions, but seems to represent only a variety of *E. mantelli* (E. T. Newton, *loc. cit.*, p. 17, pl. iv, fig. 10).

Horizons and Localities.—Turonian zones: neighbourhood of Lewes and Houghton, Sussex. Zone of *Holaster subglobosus:* Glynde and Clayton, Sussex; Burham, Kent. Zone of *Schloenbachia varians;* Dover, Kent. Undetermined zones: Brighton, Sussex; Guildford, Surrey.

3. **Edaphodon agassizi** (Buckland). Plate XLI, fig. 2.

1835–36. *Chimæra agassizii*, W. Buckland, Proc. Geol. Soc., vol. ii, p. 206, and Phil. Mag. [3], vol. viii, p. 5.

1843. *Ischyodus agassizi*, P. M. G. Egerton, Proc. Geol. Soc., vol. iv, p. 156.

1843. *Chimæra* (*Ischyodon*) *agassizii*, L. Agassiz, Poiss. Foss., vol. iii, p. 341, pl. xl*a*, figs. 3, 4 (? 5), pl. xl*c*, fig. 16 (*non* figs. 14, 15).

1844. *Chimæra*, G. A. Mantell, Medals of Creation, p. 621.

1878. *Edaphodon agassizii*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv.), p. 12, pl. iii.

1891. *Edaphodon agassizi*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. ii, p. 77.

Type.—Imperfect mandibular tooth; British Museum.

Specific Characters.—Mandibular dental plate comparatively short and stout, and the beak only slightly produced; symphysial facette scarcely occupying one-third of the inner aspect; beak-tritor composed of a series of laminæ, the other tritors consisting of numerous tubules; median tritor very broad, occupying the greater portion of the oral surface, and apparently exposed above throughout its length.

Description of Specimens.—The type specimen is so much broken along its

anterior and post-oral margins that its shape is not completely shown. A nearly perfect left mandibular dental plate, however, is represented in Pl. XLI, figs. 2, 2 *a*, 2 *b*, and exhibits all the characters of the species. Its outer face (fig. 2) is marked only by the usual structural lines, without any supplementary layer near the oral border. The symphysial facette is well marked off from the rest of the inner face (fig. 2 *a*), and in this well-preserved specimen the median tritor (*e.*) is exposed only in its upper portion, where it is continuous. The two outer tritors (fig. 2 *b*, *c.*, *d.*) are small and placed slightly within the oral margin. The upper dental plates remain unknown or unidentified.

Horizon and Localities.—Zone of *Holaster subglobosus:* Hamsey and Southeram, Sussex; Burham, Kent; Dorking, Surrey.

4. **Edaphodon reedi,** Newton. Plate XL, fig. 6.

1878. *Edaphodon reedi,* E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv.), p. 19, pl. vi.

Type.—Mandibular dental plate; York Museum.

Specific Characters.—Dental plates with tritors excessively reduced. Mandibular plate with a very prominent beak, and the symphysial facette occupying at least one-third of the inner aspect; beak-tritor composed of a series of laminæ, the other tritors consisting of numerous tubules; median tritor reduced to a small space on the edge of the symphysis; posterior outer tritor often absent. Palatine dental plate with the posterior inner tritor very small or absent, and the outer smaller than the anterior inner tritor.

Description of Specimen.—This is a large species represented by several dental plates from the Cambridge Greensand, but apparently known only by one specimen from the Lower Chalk. Even this fossil (Pl. XL, fig. 6) is not very characteristic, and exhibits an extreme reduction of the tritors. The dental plate is evidently incomplete behind, but is otherwise damaged only by a transverse fracture. There is only one diminutive, elongated inner tritor (*a.*), while the outer tritor (*c.*) is reduced to insignificance.

Horizons and Localities.—Zone of *Holaster subglobosus:* Glynde, Sussex. Cambridge Greensand.

Fin-spine of *Edaphodon.*

A large part of a dorsal fin-spine is associated with one specimen of the mandibular dentition of *E. agassizi* described by Newton (*loc. cit.*, p. 13, pl. iii, fig. 3). The fin-spine of *Edaphodon* is thus shown to resemble that of the existing *Chimæra* and also that of the typically Mesozoic genus *Ischyodus.* It is long,

slender, laterally compressed, and only slightly curved, with the flattened sides ornamented by irregular longitudinal striæ (Pl. XLI, figs. 3, 4). The anterior border is compressed to a sharp edge, which is surmounted by a slight, beaded ridge of enamel, while the grooved posterior face (fig. 4) bears a close series of downwardly-curved, enamelled denticles (fig. 4 *a*) along each edge for the greater part of its length. The spine is hollow and is cleft behind at its base, where it originally united with the supporting cartilage.

Genus **ISCHYODUS**, Egerton.

Ischyodus, P. M. G. Egerton, Proc. Geol. Soc., vol. iv, 1843, p. 155.

Generic Characters.—Mandibular dental plate usually massive, with a well-defined hard layer on the outer aspect immediately below the oral margin; its symphysial facette narrow; one anterior tritor usually present, sometimes several; one median tritor, and two or more outer tritors. Palatine plate also massive, with outer thickening; four tritors present, two being inner, one median, and one outer. Vomerine plate more or less quadrate in side view, with tritors on the oral margin; post-oral region not laterally expanded, and usually with a definite hard thickening. Dorsal fin-spine laterally compressed, more or less longitudinally ridged, sometimes even rugose, with a double series of posterior denticles. Head-spine of male short, arched, with a terminal cluster of denticles.

Type Species.—*Ischyodus townsendi* (Agassiz, Poiss. Foss., vol. iii, 1843, p. 343, pl. xl, figs. 20—22, pl. xl *c*, figs. 17, 18), from the Portlandian of S. England.

Remarks.—This genus is typically of Jurassic age, and is known by nearly complete skeletons from the Lithographic Stone of S. Germany. Only rare fragments occur in the Chalk.

1. **Ischyodus thurmanni**, Pictet and Campiche. Plate XL, fig. 7; Text-figure 56.

1843. *Ischyodus brevirostris*, P. M. G. Egerton, Proc. Geol. Soc., vol. iv, p. 156 (name only).
1843. *Chimæra* (*Ischyodon*) *brevirostris*, L. Agassiz, Poiss. Foss., vol. iii, p. 344 (name only).
1843. *Chimæra* (*Ischyodon*) *agassizii*, L. Agassiz (*errore*), *tom. cit.*, pl. xl *c*, figs. 14, 15.
1858. *Ischyodus thurmanni*, Pictet and Campiche, Foss. Terr. Cret. Ste Croix (Pal. Suisse), p. 76, pl. ix, fig. 8.
1862. *Ischyodus agassizii*, W. H. Bensted (*errore*), Geologist, vol. v, p. 378.
1867. *Ischyodus bouchardi*, H. E. Sauvage, Catal. Poiss. Second. Boulonnais (Mém. Soc. Acad. Boulogne-sur-Mer, vol. ii), p. 81, pl. iv, fig. 6.
1876. *Ischyodus brevirostris*, E. T. Newton, Quart. Journ. Geol. Soc., vol. xxxii, p. 326, pl. xxi, fig. 5.
1878. *Ischyodus brevirostris*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv.), p. 27, pl. ix.
1891. *Ischyodus thurmanni*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. ii, p. 67.

Type.—Imperfect palatine dental plate from the Gault of Switzerland.

Specific Characters.—Mandibular dental plate attaining a length of about 10 cm., very stout, with a deeply sinuous oral margin, acute eminences corresponding with the outer tritors, and the beak prominent; post-oral margin much less vertically inclined than the symphysial margin; beak-tritor minute; outer tritors well developed; median tritor narrow or of moderate width, occupying the greater part of the oral surface immediately behind the anterior outer tritor. Palatine dental plate with the posterior inner tritor of moderate or large size, and the median tritor not extending so far forwards as this; outer tritor much elongated.

Description of Specimens.—The dental plates of this species are most abundant in the Gault, whence the type specimen was obtained. Only two examples appear to be known from the English Lower Chalk. The right mandibular plate, shown of the natural size in Text-fig. 56, A, is more delicate than the typical specimens from the Gault and Cambridge Greensand (Text-fig. 56, B, C), with a narrower symphysial facette. It is also peculiar in having the post-oral margin nearly parallel with the anterior margin, and its median tritor is rather remote, being almost entirely behind the anterior outer tritor. A right palatine dental plate from Burham (Pl. XL, fig. 7) is closely similar to some of the corresponding plates from earlier Cretaceous formations referred to this species, but is noteworthy for the deep excavation of the space between the outer and anterior-inner tritors. Its median tritor does not extend so far forwards as in the type specimen from the Swiss Gault.

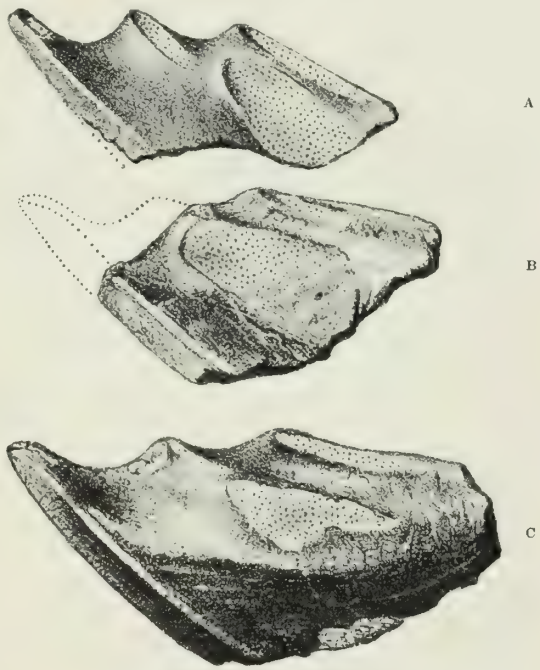


Fig. 56. *Ischyodus thurmanni*, Pictet and Campiche; three examples of right mandibular dental plate, inner or oral view, nat. size.—Zone of *Holaster subglobosus*, Isleham, near Newmarket (A); and Cambridge Greensand (B, C). After E. T. Newton.

Horizons and Localities.—Zone of *Holaster subglobosus*: Isleham, Cambridgeshire; Burham, Kent. Also Upper Greensand, Gault, Cambridge Greensand, Red Chalk, and Lower Greensand.

2. **Ischyodus (?) incisus,** Newton. Pl. XLI, figs. 5—7.

1878. *Ischyodus incisus*, E. T. Newton, Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv.), p. 38, pl. xii, figs. 3—10.

1891. *Ischyodus* (?) *incisus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. ii, p. 70.

Type.—Left mandibular dental plate; British Museum.

Specific Characters.—A small species of doubtful generic position, the mandibular plate attaining a length of about 4 cm. Mandibular dental plate much compressed, with a deeply sinuous oral margin, the beak being prominent, and pointed eminences corresponding with the outer tritors; post-oral margin partly parallel with the symphysial margin; beak-tritor subdivided into a short series; anterior outer tritor small and narrow; posterior outer tritor represented by a marginal series of minute tritors; median tritor very narrow and insignificant. Vomerine dental plate relatively broad, prominently convex externally.

Description of Specimens.—The type specimen is a much-broken mandibular dental plate in the Toulmin Smith Collection (Pl. XLI, figs. 5–5 *c*), but exhibits all the essential characters of the species. The beak-tritor (fig. 5 *c*) and the posterior outer tritor (fig. 5 *a*) are clearly subdivided, while the median tritor (fig. 5 *a*) is remarkably small. The shape of the oral border and beak and the external thickening are better seen in the original of fig. 6. The vomerine dental plate (figs. 7, 7*a*), found with the last specimen, is less nearly quadrangular than usual in *Ischyodus*, with some lateral expansion.

Horizon and Locality.—Zone of *Holaster subglobosus*: Burham, Kent.

Genus **ELASMODECTES,** Newton.

Elasmognathus, E. T. Newton (*non* J. E. Gray, 1867), Chimæroid Fishes Brit. Cret. Rocks (Mem. Geol. Surv., 1878), p. 43.

Elasmodectes, A. S. Woodward, Proc. Geol. Assoc., vol. x, 1888, p. 301.

Generic Characters.—Mandibular dental plate much laterally compressed, with no definite thickening on the outer aspect; its symphysial facette narrow; anterior tritor subdivided into small points; median tritor absent; outer tritors represented by marginal series of small points. [Palatine dental plate insufficiently known.] Vomerine plate apparently as in *Ischyodus*. Dorsal fin-spine with a sharp anterior keel, rounded sides, and posterior denticles in a single series.

Type Species.—Elasmodectes willetti, from the English Chalk.

Remarks.—This genus is known only by the type species and by an equally small species from the English Kimmeridge Clay (*Elasmodectes secans*, A. S. Woodward, Ann. Mag. Nat. Hist. [6], vol. x, 1892, p. 16, pl. iii, fig. 3).

1. **Elasmodectes willetti,** Newton. Plate XXXIX, figs. 4–6; Plate XL, figs. 1–3.

1878. *Elasmognathus willetti*, E. T. Newton, *op. cit.*, p. 43, pl. xii, figs. 13—15.

1888. *Elasmodectes willetti*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 301.

1891. *Elasmodectes willetti*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. ii, p. 88.

Type.—Mandibular dental plates; Brighton Museum.

Specific Characters.—The type species, with mandibular dental plate sometimes measuring 2·5 cm. in length, usually smaller. Mandibular plate thickest at the symphysis, with a high beak; prominences for outer tritors very gently sloping backwards, not steep; the separate points of the tritors round, irregular in size, tending to arrangement in two series in each case. Dorsal fin-spine nearly smooth, but with a tendency towards vertical ribbing, especially near the anterior keel and the base.

Description of Specimens.—This species is known chiefly by mandibular dental plates, but one specimen (Pl. XXXIX, fig. 4) exhibits part of the head and abdominal region with the characteristic dorsal fin-spine. The two mandibular plates are well preserved and shown from the inner face in the type specimen (Pl. XL, fig. 1); their outer face is seen in other examples.

The cartilages of the head and pectoral arch are only superficially calcified, and thus much broken and distorted in the chalk. The calcified layer is always very thin and consists of closely-compacted minute tesseræ. The frontal profile of the skull is steep (Pl. XXXIX, fig. 4), and in the fossil there are remains of cartilage in advance of the mouth. One of the vomerine dental plates (*v.*), displaced so as to show its inner concave face, appears to resemble the corresponding plate of *Ischyodus* in shape, with nearly parallel anterior and posterior margins, but its oral margin is broken away. The right palatine plate (*pl.*) is seen only in outer view, and the arrangement of its tritors remains unknown. Of the mandibular plate (*md.*) the outer face is nearly flat, with slight traces of growth-lines, but no thickening near the oral margin. It is completely shown in Pl. XL, figs. 1—3. The symphysis is distinctly the thickest part of the dental plate (figs. 1 *b*, 2) and the symphysial facette (fig. 3 *a*) is flattened. The post-oral margin is somewhat less steeply inclined than the symphysial margin, and on the wavy oral margin the middle prominence is nearer to the beak than to the hinder prominence. On the inner face (figs. 1, 1*a*, 3) the horizontal growth-lines are especially conspicuous, and all the tritors are visible. All the separate points of the tritors are rounded, but they are very variable in size and shape, and although they tend to arrangement in double series, they are remarkably irregular. The two series of beak tritors diverge downwards from the apex; and there is occasionally (fig. 1 *a*) a row of tritoral points along the lower half of the symphysial margin. The outer tritors extend chiefly along the gentle posterior slope of each marginal prominence, but also occur slightly on the steep anterior slope. In each case the largest points are near the apex.

The axial skeleton of the trunk is marked by the usual series of calcified rings (Pl. XXXIX, figs. 4, 4 *a*), which originally encircled the notochord.

The rostral spine is unknown, the head now described being probably that of a female. The dorsal fin-spine (Pl. XXXIX, fig. 4, *d.*), however, is seen in

contact with a piece of cartilage above the remains of the pectoral arch (*pct.*). This spine is slender and straight, and, as shown by the broken section, it is hollow for the greater part of its length, the internal cavity being especially large in its lower half. It is round in cross-section, with the anterior margin pinched off as a sharp keel. The rounded lateral face is nearly smooth, with some tendency to a longitudinal ribbing, especially near the anterior keel. In the specimens represented in figs. 4, 5, this ribbing is not conspicuous; but in another fossil (fig. 6), certainly referable to *Elasmodectes* and probably to *E. willetti*, it is so strongly marked (fig. 6 *a*) as to have caused the spine to be mistaken for *Cœlorhynchus*.[1] The hinder margin of the spine is provided with a single longitudinal series of smooth, downwardly-curved denticles, which are very close and deeply overlapping (fig. 5), and extend to within a short distance of the base. The apex of a spine with the hinder denticles apparently less crowded than usual, is figured by Dixon, Geol. Sussex, pl. xxxii,* fig. 7.

A few traces of the delicate calcified rings, which originally supported the slime-canals, are seen on the head.

Horizon and Localities.—Zone of *Holaster subglobosus:* neighbourhood of Lewes, Glynde, and Amberley, Sussex; Burham, Kent.

ICHTHYODORULITES.

Genus **CŒLORHYNCHUS,** Agassiz.

Cœlorhynchus, L. Agassiz (*non* Giorna, 1805), Poiss. Foss., vol. v, pt. i, 1844, p. 92.
Cylindracanthus, J. Leidy, Proc. Acad. Nat. Sci. Philad., 1856, p. 12.
Glyptorhynchus, M. Leriche, Mém. Mus. Roy. d'Hist. Nat. Belg., vol. iii, 1905, p. 159.

Generic Characters.—Spine very long, slender, and gradually tapering, rounded in section, and without denticles; external surface longitudinally ridged and grooved, each ridge corresponding to a wedge-shaped plate, which forms a small sector of the spine. Central cavity relatively small, sometimes in part simple, but divided by a median partition at least in the basal or proximal portion; a division-plane passing through the middle of the partition, thus allowing the spine to be readily split into two symmetrical halves.

Type Species.—*Cœlorhynchus rectus* (Agassiz, Poiss. Foss., vol. v, pt. i, 1844, p. 92), from the Eocene of Europe.

Remarks.—This fossil is commonly regarded as the rostrum of a Xiphioid teleostean, and it bears some superficial resemblance to the rostrum of *Blochius*, a fish of uncertain relationships from the Upper Eocene of Monte Bolca, near

[1] A. S. Woodward, "On the Fossil Fish-spines named *Cœlorhynchus*, Agassiz," Ann. Mag. Nat. Hist. [6], vol. ii (1888), p. 225.

Verona.[1] As shown by Williamson,[2] however, its microscopical structure seems to be that of a dermal spine. In the absence of any knowledge of its basal termination, it may therefore be placed provisionally among Ichthyodorulites. It is typically an Eocene fossil and very rare in the Chalk.

1. **Cœlorhynchus cretaceus,** Dixon. Plate XLI, figs. 8, 9.

1850. *Cœlorhynchus cretaceus,* F. Dixon, Geol. Sussex, p. xiii, pl. xxxii, fig. 10.
1888. *Cœlorhynchus cretaceus,* A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 330.

Type.—Imperfect spine; British Museum.

Specific Characters.—Smaller than the type species, with smooth and rounded or flattened longitudinal ridges. Straight and very slightly tapering.

Description of Specimens.—A new drawing of the type specimen is given in Pl. XLI, fig. 8, with part of its ornament enlarged in fig. 8 *a*. It is broken at each end, but is shown to have been very long and slender, with scarcely any tapering. The central cavity is exposed at the fractures, but the characteristic ribbing of the surface is well seen elsewhere. The ridges are nearly straight, not wavy, but they sometimes bifurcate or become double for a short distance; they are also occasionally interrupted, and the bent tapering ends lie side by side. A transverse section of another specimen, examined under a microscope (figs. 9, 9 *a*), exhibits nearly the same structure as that of the Eocene *C. rectus* as described by Williamson, *loc. cit.*; but the constituent sectors are fewer, being not more than twenty in number, and the clefts or spaces between them are larger. Minute divergent tubules are seen in each sector, but the concentric banding is less well-defined and there are no vacuities, except close to the central cavity.

Horizons and Localities.—Zone of *Holaster subglobosus:* Sussex. Senonian zone: Norwich.

Subclass ELASMOBRANCHII.

Order SELACHII.

Suborder ASTEROSPONDYLI.

Family Scyllidæ.

The small "dog-fishes" are represented by nearly complete specimens in the Upper Cretaceous of Westphalia and of Mount Lebanon, but are known only by fragments from the English Chalk. The teeth have a central cavity, as in the Carchariidæ.

[1] A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, 1901, p. 593.

[2] W. C. Williamson, Phil. Trans., 1849, p. 471, pl. xliii, figs. 35—37, and *ibid.*, 1851, p. 667.

Genus **SCYLLIUM,** Cuvier.

Scyllium, G. Cuvier, Règne Animal, vol. ii, 1817, p. 124.
Thyellina, L. Agassiz, Poiss. Foss., vol. iii, 1843, p. 378.
Scylliodus, L. Agassiz, *ibid.*, p. 377 (in part).

Generic Characters.—Anterior dorsal fin above or behind pelvic pair; origin of anal always in advance of that of the posterior dorsal fin; upper edge of caudal fin without enlarged dermal spines. Teeth small and delicate, each with a middle cusp and generally one or two pairs of conspicuous lateral denticles; several series in function at one time.

Type Species.—The existing *Scyllium canicula*, common on the British coast.

1. **Scyllium antiquum** (Agassiz). Plate XLII, figs. 1—4.

1843. *Scylliodus antiquus*, L. Agassiz, Poiss. Foss., vol. iii, p. 378, pl. xxxviii, figs. 1, 3 (*non* fig. 2).
1889. *Scyllium antiquum*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 340.

Type.—Remains of head, etc., with teeth, from zone of *Holaster subglobosus;* British Museum.

Specific Characters.—Teeth with a slender acuminate crown and a single pair of divergent, short, stout denticles. Inner coronal face in all teeth, and both faces in those placed at the back of the jaw, vertically striated. Shagreen tubercles leaf-shaped, flat and smooth.

Description of Specimen.—This species is still known only by the type specimen, which exhibits remains of the cartilages of the head, with very few teeth and some of the anterior vertebræ. Each dental crown (Pl. XLII, figs. 1—3) is rounded in section and tapers rapidly to the sharp apex, without any sigmoidal bend; it is wide below, where it is flanked by a pair of short and stout, pointed denticles, which are slightly divergent. The root of each tooth is very short but bifid, appearing as a wide arch when seen from the outer face (figs. 1—3), with each pedicle expanded at the base; it projects far inwards, and its inner apex is pierced by a large nutritive foramen (fig. 3 *a*); its lower, attached face is flattened. In the anterior teeth (fig. 1) the outer coronal face is smooth, while the inner coronal face and the whole face of both lateral denticles are marked with fine vertical striations. In the posterior teeth (fig. 2) the outer coronal face is also conspicuously striated. The figure of a tooth given by Agassiz is inaccurate and misleading.

In the vertebral centra there appears to be no calcification outside the primitive double-cone except a single peripheral layer.

A few traces of shagreen occur (Pl. XLII, fig. 4) as shining, leaf-shaped tubercles, all flat and smooth, with a small cruciform base at one end.

Horizon and Locality.—Zone of *Holaster subglobosus:* Burham, Kent.

2. **Scyllium dubium,** A. S. Woodward. Plate XLII, figs. 5, 6.

1889. *Scyllium dubium,* A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 341, pl. xvi, figs. 7, 8.

Type.—Group of teeth from zone of *Holaster subglobosus;* British Museum.

Specific Characters.—Teeth with an extremely slender crown, round in section, gently incurved, not sigmoidally bent, flanked by a single pair of very long and slender, incurved lateral denticles; outer coronal face smooth, inner face faintly marked with vertical striations in its basal half.

Description of Specimen.—This species is still known only by the type specimen, which shows clusters of teeth mingled with remains of cartilage. Even in the anterior teeth (Pl. XLII, figs. 5, 6) the lateral denticles are nearly half as deep as the crown; all the enamel is smooth and shining, while the striation in the basal half of the inner face is feeble. The root (fig. 6) is shaped as in the teeth of *S. antiquum* already described, but the expansions at the ends of the lateral pedicles are so considerable that in the original diagnosis of the species they were mistaken for an additional pair of minute denticles.

A single vertebral centrum appears to resemble that of *S. antiquum* in not having any calcification outside the primitive double-cone except a single peripheral layer.

Horizon and Locality.—Zone of *Holaster subglobosus:* Dover, Kent.

Family Ginglymostomidæ.

Genus **CANTIOSCYLLIUM,** A. S. Woodward.

Scylliodus, L. Agassiz, Poiss. Foss., vol. iii, 1843, p. 377 (in part).
Cantioscyllium, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, 1889, p. 347.

Generic Characters.—Teeth very small but stout, with a depressed root, which is scarcely bifid. Dental crown produced downwards and forwards over the root mesially, and flanked by one or two pairs of small lateral denticles. Vertebræ large, the centra short and deep in the abdominal region, conspicuously asterospondylic.

Type Species.—*Cantioscyllium decipiens,* from the English Chalk.

1. **Cantioscyllium decipiens,** A. S. Woodward. Plate XLII, figs. 7—11.

1843. *Scylliodus antiquus,* L. Agassiz (*errore*), Poiss. Foss., vol. iii, p. 378, pl. xxxviii, figs. 2, 4.
1889. *Cantioscyllium decipiens,* A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 347.
1894. *Cantioscyllium decipiens,* A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 195, pl. vi, fig. 1.
1902. *Cantioscyllium decipiens,* M. Leriche, Ann. Soc. Géol. Nord, vol. xxxi, p. 104, pl. iii, fig. 4.

Type.—Jaws, vertebræ, etc., in natural association, from zone of *Holaster subglobosus;* British Museum.

Specific Characters.—Anterior teeth with a single pair of small, stout lateral denticles; outer face marked with prominent vertical striæ in its basal half.

Description of Specimen.—This species is still known only by the type specimen (Pl. XLII, fig. 7), which displays the jaws from below, with part of the vertebral column and the pectoral arch. The cartilage is superficially calcified in small polygonal tesseræ with fringed margins, which were mistaken by Agassiz for shagreen (*loc. cit.*, fig. 4). The pterygoquadrate (*ptq.*), or cartilage of the upper jaw, is much more slender than the mandible, and bears on its outer face, within the hinder half, a small prominence (*x.*), from which seems to have been suspended a slender labial cartilage (*l.*). Each mandibular ramus (*md.*) is very deep behind, impressed by a large muscular fossa on the hinder half of its outer face; and the mandibular symphysis is rather wide. Traces of the hyoid (*hy.*) and other cartilages are seen behind the jaws, but the greater part of the branchial apparatus is destroyed. The vertebral centra in front of the pectoral arch (*pct.*) are not well shown, but just behind it they are short and deep and very clearly strengthened by radiating calcified plates. The pectoral arch (fig. 11) is a narrow transverse band of cartilage, turned sharply upwards at each end at the articulation for the fin, and its ascending portion tapering rapidly upwards to a point.

In the fossil, teeth are shown only near the symphysis. Four display the outer face (figs. 8, 9), which is conspicuously striated except near the apex. The stout lateral denticles are distinct in three of these teeth, while they are scarcely marked in the fourth. When viewed from below (fig. 10) the flattened root exhibits a large oval foramen, and the middle part of the anterior face of the crown is seen to be produced downwards.

Horizon and Locality.—Zone of *Holaster subglobosus:* Burham, Kent.

Family Lamnidæ.

The Cretaceous sharks of the family Lamnidæ are best known by associated sets of teeth and vertebræ from the Chalk of Kansas, U.S.A., and by some well-preserved small fishes (*Scapanorhynchus*) from the fissile limestone of Mount Lebanon. Nearly all the teeth and vertebræ in the English Chalk are found scattered and isolated. The teeth are always solid, without central cavity.

Genus **CORAX**, Agassiz.

Corax, L. Agassiz, Poiss. Foss., vol. iii, 1843, p. 224.
Pseudocorax, F. Priem, Bull. Soc. Géol. France [3], vol. xxv, 1897, p. 47.

Generic Characters.—Teeth compressed, more or less triangular in shape,

usually notched on the hinder border and with distinct marginal serrations. Vertebral centra strengthened by numerous concentric calcified laminæ, as in *Selache*.

Type Species.—*Corax pristodontus*, typically from the Upper Cretaceous (Danian) of Maastricht, Holland.

Remarks.—This is an essentially Upper Cretaceous genus, though the type species seems to range upwards to the Eocene in Alabama, U.S.A. The teeth are very similar in shape to those of certain Carchariidæ, such as *Sphyrna* (*Zygæna*) and *Carcharias*, but are distinguished by the absence of an internal cavity. In microscopic structure (Text-fig. 57) they agree with the teeth of the existing Lamnidæ. It is also noteworthy that with the ordinary teeth are found a few relatively small teeth, which may have occupied a gap near the front of the series in the upper jaw, as in *Lamna*, *Oxyrhina*, and *Odontaspis* (see Text-fig. 59, p. 199). The vertebral centra occur in association with teeth and pieces of cartilage in two specimens from the Niobrara Chalk of Kansas (B. M. nos. P. 9199, P. 10346). They are very short in proportion to their diameter, and are all much distorted by crushing in the fossils. As seen in cross-section, the secondary calcifications round the primitive double-cone are chiefly delicate concentric lamellæ, and there are deep wedge-shaped cavities which were originally filled by the uncalcified cartilage at the bases of the appended arches.

Fig. 57. *Corax*; vertical transverse section of tooth, highly magnified, showing the superficial gano-dentine and the vaso-dentine, without an internal cavity. After Agassiz.

1. **Corax pristodontus,** Agassiz. Plate XLII, figs. 12—15; Text-figure 58.

1843. *Corax pristodontus*, L. Agassiz, Poiss. Foss., vol. iii, p. 224, pl. xxvi, figs. 9—13.
1889. *Corax pristodontus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 423.
1891. *Corax pristodontus*, A. S. Woodward, Geol. Mag. [3], vol. viii, p. 112, pl. iii, figs. 10—16.
1894. *Corax pristodontus*, A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 198, pl. vi, figs. 16—18.

Type.—Detached teeth from the Danian of Maastricht, Holland.

Specific Characters.—The type and largest known species, the teeth sometimes measuring 3 cm. in diameter. Teeth low and broad with a very large root; anterior border gibbously arched; posterior border often not notched, only slightly concave; serrations always distinct. Root of teeth without any median cleft for a nutritive foramen on its inner face.

Description of Specimens.—An associated set of teeth discovered by M. Houzeau

de Lehaie in the phosphatic chalk of Ciply, Belgium, exhibits some of the variations which occur in different parts of the mouth (Text-fig. 58). A few of the teeth from Maastricht differ from these in having the posterior border more distinctly notched.

The only English specimens which can be referred to this species are teeth from the Upper Chalk of Norwich. The large tooth shown in Pl. XLII, fig. 12, is almost identical with certain teeth of *C. falcatus*, except in size, and the original of fig. 13 is perhaps also scarcely distinguishable; but the posterior teeth, figs. 14, 15, are more characteristic and there cannot be much doubt about their determination.

Horizon and Locality.—Zone of *Belemnitella mucronata* : Norwich.

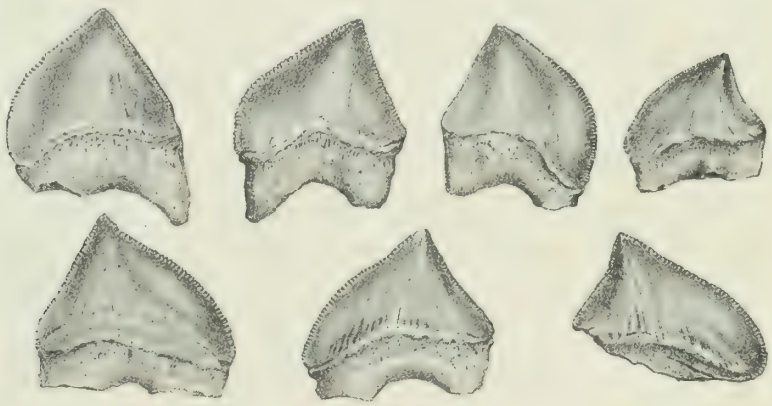


Fig. 58. *Corax pristodontus*, Agassiz; associated set of teeth, nat. size.—Danian; Ciply, Belgium. B. M. no. P. 5827.

2. **Corax falcatus,** Agassiz. Pl. XLII, figs. 16—28; Text-figure 59.

1822. *Squalus galeus* ?, G. A. Mantell, Foss. South Downs, p. 227, pl. xxxii, figs. 12—16.
1843. *Corax falcatus*, L. Agassiz, Poiss. Foss., vol. iii, p. 226, pl. xxvi, fig. 14, pl. xxvi *a*, figs. 1—15.
1850. *Corax falcatus*, F. Dixon, Geol. Sussex, pl. xxx, fig. 18.
(?) 1850. *Corax maximus*, F. Dixon, *ibid.*, p. 366, pl. xxx, fig. 17.
1889. *Corax falcatus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 424.
1894. *Corax falcatus*, A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 198, pl. vi, figs. 13—15.

Type.—Detached teeth from the Chalk of Sussex; British Museum.

Specific Characters.—Smaller than the type species. Teeth more elevated, with the anterior border usually less arched, the apex more attenuated, and the posterior border more sharply notched; serrations distinct, except in very small teeth, where they are sometimes feeble or perhaps absent. Root of teeth without any median cleft for a nutritive foramen on its inner face.

Description of Specimens. — Three of the type specimens in the Mantell Collection are re-figured in Pl. XLII, figs. 16—18, and exhibit the characteristic features of a sharp notch behind, a slightly curved border in front. The low-

crowned posterior tooth (fig. 17) may be compared with that of *C. pristodontus* (fig. 15), and the relative slenderness of its apical portion will be noted. Another tooth with a gently excavated posterior border (fig. 19) is comparable with fig. 14, and is evidently distinguishable by its greater height in proportion to its width. The large tooth shown in fig. 20 corresponds closely with that of fig. 12, but has a less gibbous anterior border and a more attenuated apex. Another large notched tooth (fig. 22) exhibits the characteristic elevation and apical slenderness; and the four smaller teeth from lower horizons in the Chalk, shown in figs. 23—26, are also typical. A comparatively small upright tooth from Eastbourne (fig. 27) is sharply notched near the base behind, and more gently notched in front. Its

Fig. 59. *Corax falcatus*, Agassiz; outlines of associated set of teeth, nat. size.—Upper Cretaceous (Niobrara Group); Kansas, U.S.A. C. H. Sternberg Collection (B.M. no. P. 10346).

outer face is exposed, and the root is shown to be slightly forked. A second example, apparently of the same tooth, is exhibited from the inner face (fig. 28) and shows that there is no median cleft for a nutritive foramen in the root. These two small teeth may probably be referred to the anterior gap in the upper dental series.

The relatively large tooth from Houghton, Sussex, named *Coraæ maximus* by Dixon, is imperfect at the base behind where the notch would occur (fig. 21). It seems to be only a tooth of *C. falcatus* of unusual size.

Teeth resembling those named *Coraæ falcatus* have an almost world-wide distribution in Upper Cretaceous deposits; and in the Chalk of Kansas large groups have been found associated with pieces of calcified cartilage and vertebral centra. A selected series from one such group of naturally associated teeth is shown in

Text-fig. 59, and illustrates some of the variations which occur in different parts of the mouth. The upright tooth at the left-hand upper corner of the figure is specially noteworthy, being comparatively small and doubtless referable to the anterior gap in the upper dental series.

Horizons and Localities.—Universal, in all zones from that of *Actinocamax quadratus* downwards. Also Upper Greensand and Cambridge Greensand.

3. **Corax jaekeli,** A. S. Woodward. Plate XLIII, figs. 1—3.

1895. *Galeocerdo jaekeli,* A. S. Woodward, Ann. Mag. Nat. Hist. [6], vol. xv, p. 4, pl. i, figs. 5—7.

Type.—Tooth; British Museum.

Specific Characters.—Teeth comparatively small, very low and broad, with the apex of the crown turned sharply backwards. Anterior border of crown gently arched, with relatively large, though sometimes feebly marked, serrations in its lower half; apex above posterior notch small and narrow; posterior border below notch with seven to eleven coarse serrations, decreasing in size backwards. Root with a slight median cleft for a nutritive foramen on its inner face.

Description of Specimens.—The type specimen and the other two teeth of this species originally described, were of uncertain origin; but the three additional specimens shown in Pl. XLIII, figs. 1—3, were obtained by Dr. H. P. Blackmore from the uppermost zones of the English Chalk. The shortest and deepest tooth (fig. 1), which is probably referable to an anterior position in the jaw, has a remarkably arched base; and the apical part of the crown is scarcely larger than the uppermost of the eight denticles on its posterior border. Its anterior border, which is comparatively steep, is coarsely serrated in the lower half. The second tooth (fig. 2) is less deep, with a relatively larger apical portion, and larger anterior serrations. The base-line of its crown is less strongly arched, but the stout root is still somewhat forked. The third tooth (fig. 3) is again less elevated, with a wide extent along its arched root, and more numerous serrations on both anterior and posterior borders. As already described, the type specimen exhibits the slight median cleft on the inner face of its root where a nutritive foramen enters.

In the original description the teeth of this form were provisionally referred to the genus *Galeocerdo;* but Dr. Blackmore has kindly permitted the tooth shown in fig. 1 to be cut across, so that its structure may be examined. This section proves that the tooth is solid, and thus cannot belong to any genus of Carchariidæ. Its internal vaso-dentine resembles that of the Lamnidæ and Notidanidæ; and it is excluded from the latter family by the shape of the root. Among known genera of Lamnidæ the tooth can only be assigned to *Corax.*

Horizons and Localities.—Zones of *Marsupites* (*Uintacrinus*-band) and *Actinocamax quadratus:* neighbourhood of Salisbury, Wiltshire. Also from Chalk of Kent.

4. **Corax affinis,** Agassiz. Pl. XLIII, figs. 4—9.

1843. *Corax affinis,* L. Agassiz, Poiss. Foss., vol. iii, p. 227, pl. xxvi, fig. 2, pl. xxvi *a*, figs. 21—24.
1843. *Corax appendiculatus,* L. Agassiz, *tom. cit.*, p. 227, pl. xxvi, fig. 3.
1843. *Corax planus,* L. Agassiz, *tom. cit.*, p. 229, pl. xxvi *a*, figs. 51—57.
1854. *Sphyrna plana,* E. Hébert, Mém. Soc. Géol. France [2], vol. v, p. 354, pl. xxvii, fig. 9.
1889. *Corax affinis,* A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 427.
1894. *Corax affinis,* A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 199, pl. vi, figs. 19—22.
1897. *Pseudocorax affinis,* F. Priem, Bull. Soc. Géol. France [3], vol. xxv, p. 46, pl. i, figs. 20—27.
1902. *Pseudocorax affinis,* M. Leriche, Ann. Soc. Géol. Nord, vol. xxxi, p. 122, pl. iii, figs. 79—86.
1906. *Pseudocorax affinis,* var. *lævis,* M. Leriche, Mém. Soc. Géol. Nord, vol. v, p 80.

Type.—Detached teeth from the Danian of Maastricht, Holland.

Specific Characters.—Teeth comparatively small, the crown more slender and elevated than in the other species, notched prominently at the base of the hinder border and less so at the anterior border, thus producing a broad posterior denticle and a less distinct anterior denticle; serrations feeble or absent. Root with a slight median cleft for a nutritive foramen on its inner face.

Description of Specimens.—The margins of the typical teeth from the Danian of Maastricht seem to be always distinctly serrated; while those of the teeth from the Upper Senonian of Belgium, France, and England are merely very thin, often crimped or jagged, but not truly serrated. Leriche (1906) therefore regards the earlier teeth, such as those now to be described, as belonging to a well-marked variety, which he names *lævis*. The upper part of the dental crown is sometimes sufficiently translucent to show by transmitted light the mineral-stained coarse network of vascular canals, which traverse the internal core of vaso-dentine. Sections have proved that there is no internal cavity.

An anterior tooth (Pl. XLIII, fig. 4) has the crown only slightly inclined, with the anterior denticle almost as distinct and large as the posterior denticle. Another anterior tooth (fig. 5), with the crown more inclined and the anterior denticle less marked, is interesting as showing the small and partially bifid root. A third high-crowned tooth (fig. 6) is broader, and exhibits well the peculiar curvature of the anterior and posterior borders; its root is imperfect below. The inner view of a tooth from a position further back in the jaw (fig. 7) displays the slight cleft in the root above its bifurcation. Two still broader teeth are shown from the outer and inner aspects respectively in figs. 8, 9.

Teeth of this form are regarded as generically distinct from *Corax* by Priem (1897) and Leriche (1902), who describe them as the type of a previously

unrecognised genus, *Pseudocorax*. While ignorant, however, of the shape and characters of the shark to which these teeth belong, it seems premature to multiply generic names.

Horizons and Localities.—Zone of *Belemnitella mucronata:* Norwich. Zone of *Marsupites:* Sussex (A. W. Rowe).

Genus **OXYRHINA**, Agassiz.

(?) *Isurus*, Rafinesque, Caratt. Alcuni Nuovi Generi, 1810, p. 11.
Oxyrhina, L. Agassiz, Poiss. Foss., vol. iii, 1838, p. 86.
Xenodolamia, J. Leidy, Journ. Acad. Nat. Sci. Philad., [2] vol. viii, 1877, p. 251.

Generic Characters.—Teeth large, lanceolate in front of mouth, triangular and much compressed at sides and in hinder part of jaws, without lateral denticles; border of crown not serrated.

Type Species.—An existing shark, *Oxyrhina spallanzanii*.

Remarks.—The species of this genus are widely distributed in existing seas. Teeth occur in nearly all marine deposits of Upper Cretaceous and Tertiary age.

1. **Oxyrhina mantelli**, Agassiz. Plate XLIII, figs. 10—15; Text-figures 60, 61.

1822. *Squalus zygæna* (?), G. A. Mantell, Foss. South Downs, p. 227, pl. xxxii, figs. 4, 7, 8, 10, 11, 26, 28.
1839. *Lamna mantelli*, G. A. Mantell, Wonders of Geology, pp. 328, 426, lign. 58, fig. 2.
1843. *Oxyrhina mantelli*, L. Agassiz, Poiss. Foss., vol. iii, p. 280, pl. xxxiii, figs. 1—5, 7—9 (*non* fig. 6).
1843. *Lamna acuminata*, L. Agassiz, *tom. cit.*, p. 292, pl. xxxvii *a*, fig. 54 (? *non* figs. 55—57).
1850. *Oxyrhina mantelli*, F. Dixon, Geol. Sussex, pl. xxx, fig. 24.
1850. *Lamna acuminata*, F. Dixon, *ibid.*, pl. xxx, fig. 19.
1873. *Oxyrhina extenta*, J. Leidy, Extinct Vert. Fauna W. Territ. (Rep. U.S. Geol. Surv. Territ., vol. i, pt. i), p. 302, pl. xviii, figs. 21—25.
1889. *Oxyrhina mantelli*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 376, pl. xvii, figs. 9—21.
1894. *Oxyrhina mantelli*, C. R. Eastman, Palæontogr., vol. xli, p. 149, pls. xvi—xviii.
1902. *Oxyrhina mantelli*, M. Leriche, Ann. Soc. Géol. Nord, vol. xxxi, p. 116, pl. iii, figs. 49—53.

Type.—Imperfect detached teeth from the Chalk of Sussex; British Museum.

Specific Characters.—A species of moderate size, the crown of the anterior teeth usually not exceeding 3 cm. in height. Teeth rather stout; outer coronal face always nearly flat, often with a few large vertical wrinkles; inner coronal face gently rounded; root short, the branches very divergent, thick, expanded, and abbreviated. Anterior teeth large and comparatively broad, the crown only gently curved outwards at the apex; lateral teeth with the root much wider than the main portion of the crown, which thus exhibits a sudden basal expansion behind, often also in front.

Description of Specimens.—The type specimens in the Mantell Collection are detached anterior teeth, mostly imperfect, but an associated set of over fifty teeth, found with vertebræ in the Upper Chalk of Grays, displays the principal characters of the whole dentition of the species. Thirteen of these teeth are shown of the natural size in the accompanying Text-fig. 60, representing various parts of the mouth. Some anterior teeth are narrower and more lanceolate than the foremost here seen, while some of the posterior teeth are still smaller than the two low-

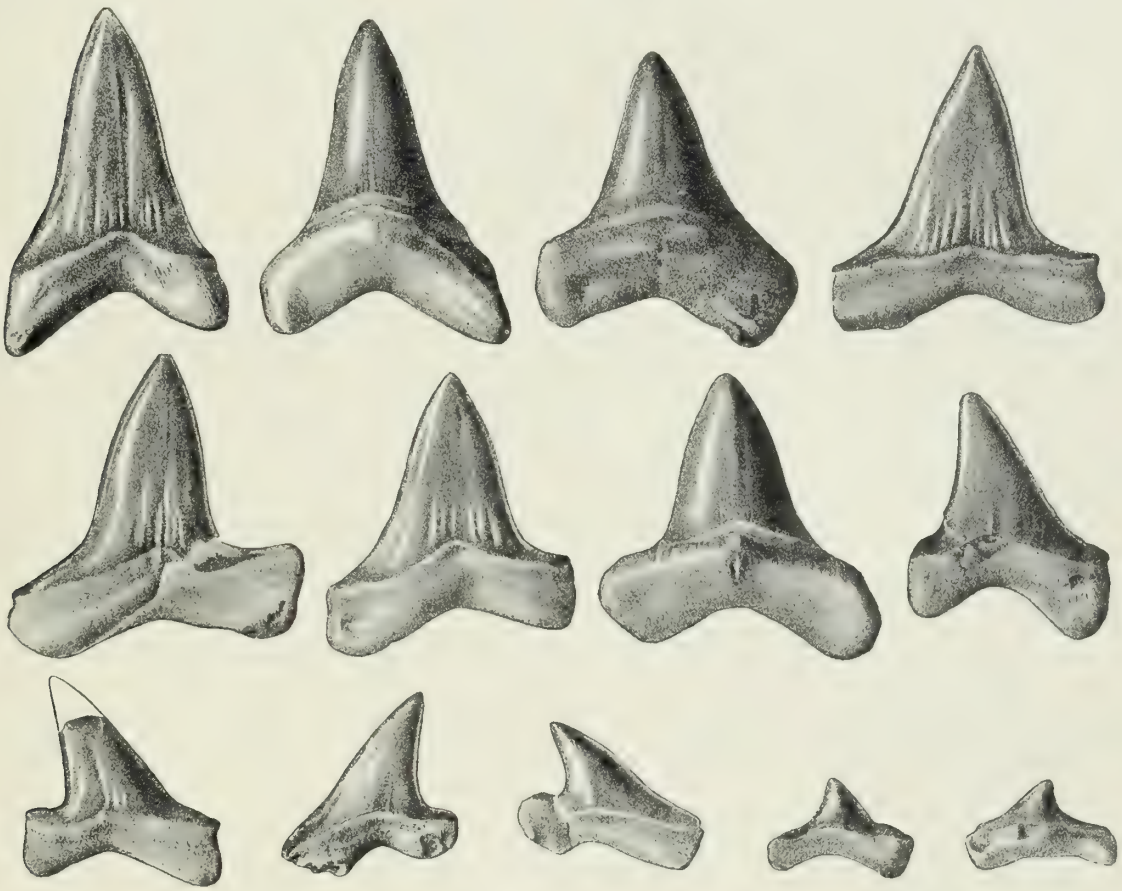


Fig. 60. *Oxyrhina mantelli*, Agassiz; associated set of teeth, nat. size.—Zone of *Micraster coranguinum*; Grays, Essex. Bowerbank Collection (B. M. nos. 32347, 39434).

crowned specimens at the end of this selected series. The vertical wrinkles in the basal half of the outer face of the crown are indicated in five of the drawings.

An associated set of nearly three hundred teeth evidently of the same species, from the Niobrara Chalk of Kansas, U.S.A., has been studied by Eastman (1894), who considers that they were probably arranged in the jaws as shown in the diagram, Text-fig. 61. With these normal teeth in the Kansas specimen there are also eleven very small distorted teeth with a root as squat as that of the English Chalk fossil represented in Pl. XLIII, fig. 10. Such teeth were originally described by Leidy under the name of *Xenodolamia*, but there can be no longer any

doubt as to their pertaining to *Oxyrhina*, although their position in the jaw remains uncertain. Eastman regards them as symphysial teeth.

Teeth of *Oxyrhina* occasionally exhibit small lateral denticles, and a few examples may be noted in *O. mantelli*. One anterior tooth (Pl. XLIII, fig. 11) and a postero-lateral tooth (fig. 12) bear a single pointed denticle posteriorly, while an apparently antero-lateral tooth (fig. 13) shows an indistinct crimping of the slightly expanded base in front, with one separate denticle followed by some crimping behind. There cannot be much doubt, indeed, that the small lateral teeth named *Lamna acuminata* by Agassiz and Dixon, are really referable to *Oxyrhina mantelli*.

As already mentioned, portions of vertebral centra occur with the group of teeth of this species from Grays, and are clearly similar to those described by Eastman in the specimen from Kansas. Such vertebræ are common in the Chalk, and two specimens are shown, in upper view and vertical transverse sections

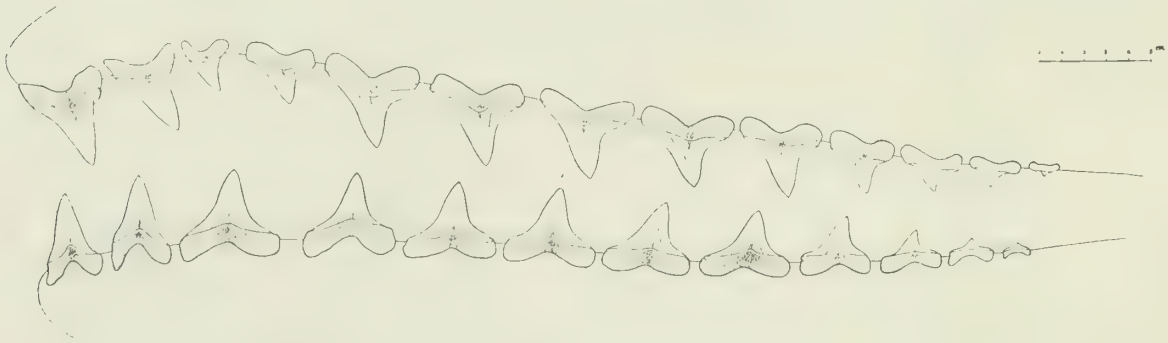


Fig. 61. *Oxyrhina mantelli*, Agassiz; upper and lower dentition as restored by Dr. Charles R. Eastman, much reduced in size. Upper Cretaceous (Niobrara Group); Kansas, U.S.A.

respectively, in Pl. XLIII, figs. 14, 15. All the secondary calcifications within the primitive double cone are radiating plates, which usually bifurcate towards the periphery of the centrum.

Horizons and Localities.—Universal, all zones from that of *Actinocamax quadratus* downwards. Also Upper Greensand and Cambridge Greensand.

2. **Oxyrhina angustidens,** Reuss. Plate XLIII, figs. 16—20.

1845. *Oxyrhina angustidens*, A. E. Reuss, Verstein. böhm. Kreideform., pt. i, p. 6, pl. iii, figs. 7—13.
1845. *Oxyrhina acuminata*, A. E. Reuss, *op. cit.*, pt. i, p. 7, pl. iii, figs. 17—19, pl. vii, fig. 20.
1845. *Oxyrhina heteromorpha*, A. E. Reuss, *op. cit.*, pt. i, p. 7, pl. iii, figs. 14–16.
1846. *Scoliodon priscus*, A. E. Reuss, *op. cit.*, pt. ii, p. 100, pl. xxiv, figs. 23, 24, pl. xlii, figs. 10–12.
1889. *Oxyrhina angustidens*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 380.
1894. *Oxyrhina angustidens*, A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 197, pl. v, figs. 20—23.
1902. *Oxyrhina angustidens*, M. Leriche, Ann. Soc. Géol. Nord, vol. xxxi, p. 117, pl. iii, figs. 59—65.

Type.—Detached teeth from the Cenomanian of Bohemia.

Specific Characters.—A very small species, the crown of the anterior teeth only attaining a height of about 1·2 cm. Dental crown always very narrow and deep, extending along the wider root at its base; the divergent branches of the root considerably elongated in the teeth near the symphysis.

Description of Specimens.—This species is known only by detached teeth, of which a selection from the English Chalk is shown in Pl. XLIII, figs. 16—20. Even in the symphysial teeth (figs. 16, 17) the crown widens at its base into a short extension along the root both in front and behind. The crown in these teeth has a very slight sigmoidal bend, while the root exhibits a cleft for the nutritive foramen on its inner face (fig. 16). In the lateral and hinder teeth (figs. 18—20) the crown is still remarkably narrow and very little inclined, but the inner face of the root does not appear to be marked by a cleft. The crown is always extremely smooth, with thin, sharp edges.

Horizons and Localities.—Zone of *Terebratulina gracilis:* Whyteleafe, Surrey (G. E. Dibley). Zone of *Holaster subglobosus:* Burham and Halling, Kent; Glynde, Sussex; Oxted and Guildford, Surrey; Cherry Hinton, Cambridgeshire. Zone of *Schloenbachia varians:* Dover, Kent. Also Upper Greensand and Cambridge Greensand.

3. **Oxyrhina crassidens,** Dixon. Plate XLIV, figs. 1, 2.

1843. *Oxyrhina mantelli,* L. Agassiz (*errore*), Poiss. Foss., vol. iii, pl. xxxiii, fig. 6.
1850. *Oxyrhina crassidens,* F. Dixon, Geol. Sussex, p. 367, pl. xxxi, fig. 13.
1889. *Oxyrhina crassidens,* A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 382.

Type.—Nearly complete tooth from a Turonian zone; British Museum.

Specific Characters.—Teeth extremely robust, of large size, the crown attaining a height of about 4 cm. Dental crown narrow and deep, extending at its base along the wider root, where its edge is usually coarsely crimped; outer coronal face irregularly convex, with few vertical wrinkles; inner face extremely convex and smooth, but with fine, short basal wrinkles. Root of tooth with a considerable inward prominence immediately below the base of the crown, and only a faint shallow groove for the nutritive foramen.

Description of Specimens.—The type tooth in the Dixon Collection (Pl. XLIV, fig. 1) is noteworthy for the excessive crimping of its lateral basal extension on the side best preserved, and its inner face shows clearly the fine vertical wrinkles at the lower border of the crown (fig. 1*a*). A more elevated and less robust tooth (Pl. XLIV, fig. 2), evidently from a more anterior position in the jaw, has a less crimped lateral basal extension, but its inner face (fig. 2 *a*) is similarly wrinkled at the base. More than half of its root is well preserved, showing the characteristic inward prominence and the faint shallow groove on the middle of its inner

face. One dental crown is wrongly ascribed by Agassiz, *loc. cit.*, to *Oxyrhina mantelli*. A small group of associated teeth from Lewes in the Willett Collection, Brighton Museum, does not exhibit any remarkable variations.

Horizons and Localities.—Turonian zones: Lewes, Houghton, and Arundel, Sussex.

Genus **LAMNA**, Cuvier.

Lamna, G. Cuvier, Règne Animal, vol. ii, 1817, p. 126.
Otodus, L. Agassiz, Poiss. Foss., vol. iii, 1843, p. 266 (in part).

Generic Characters.—Posterior dorsal fin and anal fin very small. A pit at the root of the caudal fin, which has the lower lobe much developed; side of the tail with a keel. Teeth (except the hindmost of the series) with a high and narrow

Fig. 62. *Lamna cornubica* (Linnæus); upper and lower dentition, about one-half nat. size.—Existing.

compressed crown, not serrated, but flanked with one or two denticles; root bifid. On each side of the upper jaw, at a short distance from the symphysis, one or two teeth comparatively small.

Type Species.—An existing shark, *Lamna cornubica*.

Remarks.—The dentition of the type species is shown in the accompanying Text-fig. 62. It can scarcely be distinguished from that of a closely related genus *Odontaspis*, but differs in the less elevated and less subulate character of its anterior teeth, and in the usually larger size of the lateral denticles.

1. **Lamna appendiculata**, Agassiz. Plate XLIV, figs. 3—7; Text-figures 63, 64.

1822. *Squalus mustelus* ?, G. A. Mantell, Foss. South Downs, pl. xxxii, figs. 2, 3, 5, 6, 9.
1835. *Lamna appendiculata*, L. Agassiz, Poiss. Foss., Feuill, p. 54.
1843. *Otodus appendiculatus*, L. Agassiz, Poiss. Foss., vol. iii, p. 270, pl. xxxii, figs. 1—25.
1850. *Otodus appendiculatus*, F. Dixon, Geol. Sussex, pl. xxx, fig. 25, pl. xxxi, fig. 17.
1889. *Lamna appendiculata*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 393.
1894. *Lamna appendiculata*, A. S. Woodward, Proc. Geol. Assoc., vol xiii, p. 197, pl. v, fig. 25, pl. vi, fig. 2.
1902. *Lamna appendiculata*, M. Leriche, Ann. Soc. Géol. Nord, vol. xxxi, p. 111, pl. iii, figs. 28—38.

Type.—Detached teeth probably from Turonian zones near Lewes; British Museum.

Specific Characters.—Teeth robust, sometimes attaining a total height of 4 cm., but usually smaller. Outer coronal face slightly convex or flat, often with few indefinite vertical folds in the basal half; inner coronal face very convex, smooth; cutting edges prominent; a single pair of lateral denticles, broad but pointed.

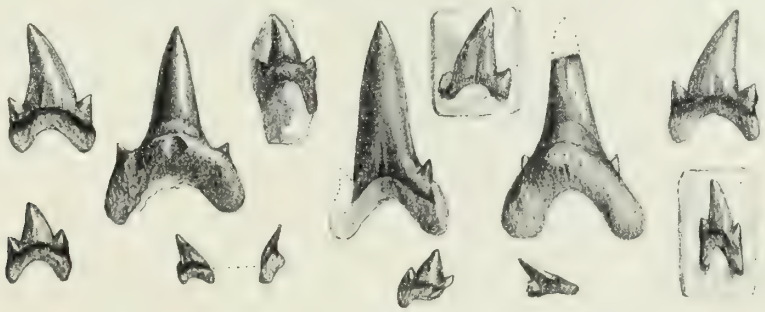


Fig. 63. *Lamna appendiculata*, Agassiz; associated set of teeth, nat. size.—Zone of *Holaster subglobosus*; Dover. Gardner Collection (B. M. no. P. 45).

Root very thick, having a much-flattened postero-inferior face, with no groove for the nutritive foramen. Anterior teeth narrow and upright; hinder lateral teeth much inclined backwards, the anterior edge being more arcuate and longer than the posterior edge.

Description of Specimens.—Most of the detached teeth selected by Agassiz as the type specimens of this species were obtained by Mantell from the Chalk near

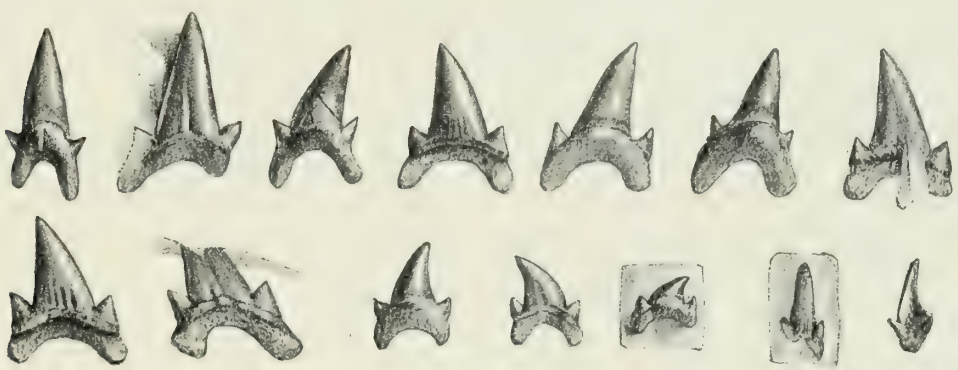


Fig. 64. *Lamna appendiculata*, Agassiz; associated set of teeth, nat. size.—Zone of *Holaster subglobosus*; near Maidstone. Bowerbank Collection (B. M. no. 39053).

Lewes. The variations in shape in different parts of the jaw correspond with those observable in the dentition of the existing *Lamna* (Text-fig. 62), as shown by the associated sets of teeth represented in Text-figs. 63, 64. In both these specimens there is a diminutive robust tooth, with a narrow elevated crown and closely adpressed lateral denticles, evidently the same as the dwarfed tooth which always occurs in *Lamna* in the third place from the front of the upper jaw. In the

first specimen there are also some of the very small hindmost teeth without lateral denticles.

Some teeth with nearly upright crowns (Pl. XLIV, figs. 3, 4) are less sharply pointed than those in the two groups just mentioned. An accessory pair of minute outer cusps is extremely rare (fig. 5). The larger teeth (fig. 6) are very stout, but usually exhibit all the peculiar features of the species. A few of them (fig. 7) are wrinkled on the outer face almost as much as in *L. sulcata*, and one tooth figured by Dixon (*op. cit.*, pl. xxxi, fig. 17) makes a close approximation to the front teeth of the latter species.

Horizons and Localities.—Universal, all zones. Also Upper Greensand, Cambridge Greensand, and Gault.

2. **Lamna arcuata,** A. S. Woodward. Plate XLIV, figs. 8, 9.

1894. *Lamna arcuata*, A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 198, pl. vi, fig. 10.
1897. *Lamna arcuata*, F. Priem, Bull. Soc. Géol. France, [3] vol. xxv, p. 42, pl. i, figs. 10, 11.

Type.—Tooth from zone of *Belemnitella mucronata*; British Museum.

Specific Characters.—Crown of teeth comparatively slender, narrow, and acute, moderately compressed, smooth, and somewhat bent in the principal lateral teeth; a single pair of large acuminate lateral denticles; root small, but forming a considerable inward prominence without any groove for the nutritive foramen.

Description of Specimens.—The type tooth is shown from the outer and lateral aspects in Pl. XLIV, figs. 8, 8 *a*, and is probably referable to the middle of the side of the jaw. The enamel of the crown and denticles is completely smooth. The inner prominence of the root has a flattened lower face. A second specimen (figs. 9, 9 *a*) is more slender, with a less deepened root.

Horizon and Locality.—Zone of *Belemnitella mucronata:* Norwich.

3. **Lamna semiplicata** (Agassiz). Plate XLIV, figs. 10, 11.

1843. *Otodus semiplicatus*, L. Agassiz (*ex* Münster, MS.), Poiss. Foss., vol. iii, p. 272, pl. xxxvi, fig. 32 (? fig. 33).
1888. *Otodus semiplicatus*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 292.
1889. *Lamna semiplicata*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 397.
1894. *Lamna semiplicata*, A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 197, pl. vi, figs. 3, 4.
1902. *Otodus semiplicatus*, M. Leriche, Ann. Soc. Géol. Nord, vol. xxxi, p. 114, pl. iii, fig. 48.

Type.—Base of tooth from the Cenomanian of Saxony; Palæontological Museum, Munich.

Specific Characters.—Teeth robust, of large size, the crown sometimes 3 cm. in height. Outer coronal face even, flat or slightly convex; a series of short

parallel vertical wrinkles on the basal portion of the crown both on the outer and inner face; a single pair of very broad lateral denticles, sometimes incompletely subdivided; root with a considerable inward prominence immediately below the base of the crown, and not more than a faint groove for the nutritive foramen.

Description of Specimens.—Only two well-preserved teeth are known from the English Chalk, one (Pl. XLIV, fig. 10) with the crown more elevated than the other (fig. 11). They exhibit all the characters noted in the specific diagnosis above. In each specimen there is a slight denticulation between the main cusp of the crown and the acuminate lateral denticle.

Horizons and Localities.—Undetermined zones in the Chalk of Rochester and Charing, Kent. Zone of *Holaster subglobosus:* Merstham, Surrey.

4. **Lamna sulcata** (Geinitz). Plate XLIV, figs. 12, 13.

1843. *Otodus sulcatus*, H. B. Geinitz, Charakt. Schicht. u. Petrefakt. sächs.-böhm. Kreidegeb., Nachtr., p. 5, pl. iv, fig. 2.
1846. *Otodus sulcatus*, A. E. Reuss, Verstein. böhm. Kreideform., pt. ii, p. 100, pl. xxi, fig. 41.
1872. *Otodus sulcatus*, H. E. Sauvage, Biblioth. Ecole Hautes Etudes, vol. v, no. 9, p. 29, figs. 60—69.
1872. *Otodus pinguis*, H. E. Sauvage, *ibid.*, p. 31, figs. 70—72.
1873. *Otodus divaricatus*, J. Leidy, Extinct Vert. Fauna W. Territ. (Rep. U. S. Geol. Surv., vol. i, pt. i), p. 305, pl. xviii, figs. 26—28.
1889. *Lamna sulcata*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 398.
1894. *Lamna sulcata*, A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 197.
1902. *Otodus sulcatus*, M. Leriche, Ann. Soc. Géol. Nord, vol. xxxi, p. 115, pl. iii, fig. 47.
1906. *Otodus semiplicatus=Otodus sulcatus*, M. Leriche, Mém. Soc. Géol. Nord, vol. v, p. 62.

Type.—Tooth from the Cenomanian of Saxony; Dresden Museum.

Specific Characters.—Teeth resembling those of *Lamna semiplicata*, but their convex outer face more uneven, and both faces with longer, stronger, and more irregular vertical wrinkles.

Description of Specimens.—A nearly complete anterior tooth is shown in Pl. XLIV, figs. 12, 12*a*. The crown exhibits a slight sigmoidal bend, and its edges are remarkably acute. Its outer face is strongly marked with irregular wrinkles in the lower portion. Its lateral denticles are high and acuminate, also irregularly wrinkled in the basal half. A much wider tooth, from a more posterior position in the jaw, is shown in fig. 13, also marked on the outer face with conspicuous, irregular wrinkling. Several imperfect teeth are known with the same characters.

Remarks.—Leriche considers that the teeth of this form are merely an extreme variety of those named *L. semiplicata*. He also doubts the correctness of their reference to *Lamna*, and prefers to retain them in the so-called genus *Otodus*. Apart from their possession of well-marked lateral denticles, they bear a most

striking resemblance to the teeth commonly described as *Oxyrhina crassidens* (see p. 205).

Horizons and Localities.—Turonian zones: near Lewes, Sussex; Cuxton, Kent; Surrey.

Genus **SCAPANORHYNCHUS,** A. S. Woodward.

Rhinognathus, J. W. Davis (*non* Fairmaire, 1873), Trans. Roy. Dublin Soc. [2], vol. iii, 1887, p. 480.
Scapanorhynchus, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, 1889, p. 351.

Generic Characters.—Body slender, with much elongated snout. Posterior dorsal fin small, opposed to an extended anal fin; caudal fin much elongated,

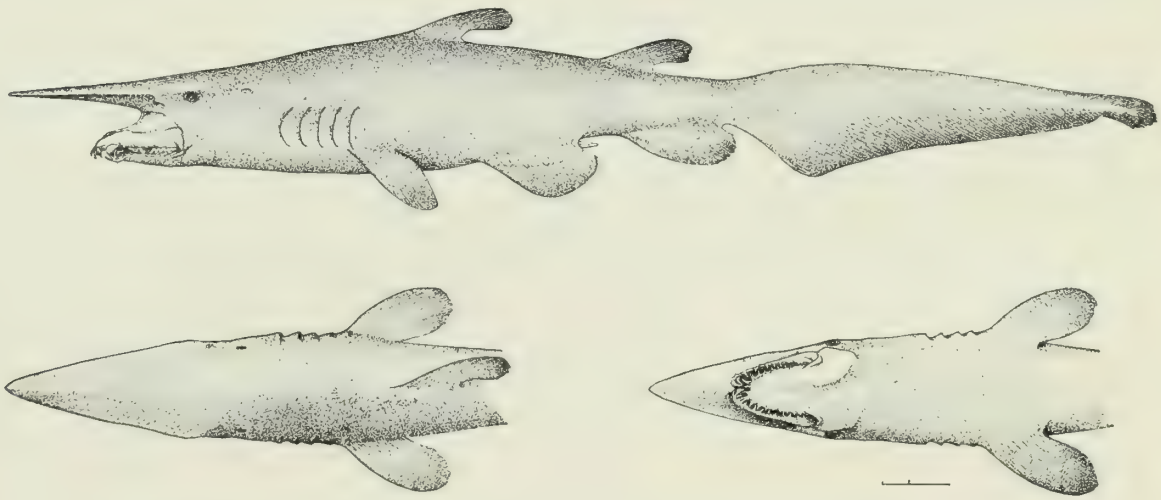


Fig. 65. *Mitsukurina owstoni*, Jordan; young male in side view, with upper and lower views of head, etc., greatly reduced in size.—Existing in Japanese Seas. After D. S. Jordan.

inferiorly notched near the extremity. Teeth with a high and slender cuspidate crown, mostly with a pair of small lateral denticles; root bifid.

Type Species.—*Scapanorhynchus lewisi* (J. W. Davis, *loc. cit.*, 1887, p. 480, pl. xiv, fig. 4, and A. S. Woodward, *loc. cit.*, 1889, p. 351, pl. xvii, figs. 1—7), known by imperfect fishes from the Upper Cretaceous of Mount Lebanon.

Remarks.—This genus is closely related to, if not identical with, *Mitsukurina* (Text-fig. 65), a genus of sharks existing in the deep sea off Japan.[1] The crushed

[1] D. S. Jordan, "Description of a Species of Fish (*Mitsukurina owstoni*) from Japan, the Type of a Distinct Family of Lamnoid Sharks," Proc. California Acad. Sci., [3] Zool., vol. i, no. 6 (1898); A. S. Woodward, "Note on *Scapanorhynchus*, a Cretaceous Shark apparently surviving in Japanese Seas," Ann. Mag. Nat. Hist., [7] vol. iii (1899), pp. 487—489; B. A. Bean, "Notes on an Adult Goblin Shark (*Mitsukurina owstoni*) of Japan," Proc. U. S. Nat. Mus., vol. xxviii (1905), pp. 815—818; L. Hussakof, "A New Goblin Shark, *Scapanorhynchus jordani*, from Japan," Bull. Amer. Mus. Nat. Hist., vol. xxvi (1909), pp. 257—262, pl. xliv.

specimens from the Chalk of Mount Lebanon (Text-figs. 66, 67) exhibit most of its principal characters; but detached teeth alone have been discovered in the English Chalk. Similar teeth occur in marine Cretaceous formations in all parts of the world.

Fig. 66. *Scapanorhynchus elongatus*, A. S. Woodward (A) and *Scapanorhynchus lewisi* (Davis) (B); lower views of head with rostrum, two-thirds nat. size, with teeth enlarged.—Upper Cretaceous; Sahel Alma, Mount Lebanon. Lewis Collection (B. M. nos. P. 4774, 49474).

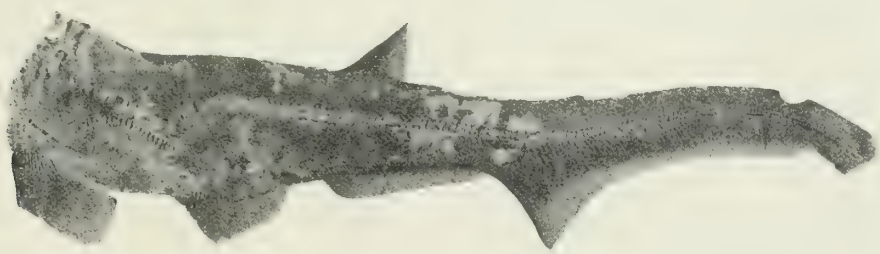


Fig. 67. *Scapanorhynchus lewisi* (Davis); imperfect trunk, about one-third nat. size.—Upper Cretaceous; Sahel Alma, Mount Lebanon. Lewis Collection (B. M. no. P. 4020).

1. **Scapanorhynchus rhaphiodon** (Agassiz). Plate XLIV, figs. 14—17.

1843. *Lamna* (*Odontaspis*) *rhaphiodon*, L. Agassiz, Poiss. Foss., vol. iii, p. 296, pl. xxxvii *a*, figs. 12—16 (*non* fig. 11).

1850. *Odontaspis rhaphiodon*, F. Dixon, Geol. Sussex, pl. xxx, fig. 32.

1872. *Odontaspis rhaphiodon*, H. E. Sauvage, Biblioth. Ecole Hautes Etudes, vol. v, no. 9, p. 36, pl. i, figs. 42—53.

1889. *Scapanorhynchus rhaphiodon*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 353.

1894. *Scapanorhynchus rhaphiodon*, A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 196, pl. v, figs. 11—13.

1902. *Scapanorhynchus* (*Odontaspis*) *rhaphiodon*, M. Leriche, Ann. Soc. Géol. Nord, vol. xxxi, p. 106, pl. iii, figs. 8—13.

Type.—Dental crowns, probably from a Turonian zone; British Museum.

Specific Characters.—Crown of anterior teeth usually attaining a height of from 1·5 cm. to 2 cm. Inner coronal face marked with prominent vertical striæ,

which are not all parallel; root prominent on the inner face, with a sharp median groove. Anterior teeth without lateral denticles; postero-lateral teeth with a single pair of sharp denticles.

Description of Specimens.—The teeth of this species are so delicate that the root is often lost in the fossils, leaving isolated crowns in the same condition as in the type specimens. They are easily recognised by the peculiar vertical striation which covers the greater part of the inner coronal face (Pl. XLIV, fig. 15 *a*). The sharp striæ are closely arranged at the base, but many of them terminate at a short distance upwards, while those which persist diverge towards their upper end, where they often admit other short intercalated striæ. The crown in the anterior teeth (Pl. XLIV, figs. 14, 15) is always sigmoidally bent, sometimes excessively so (fig. 16). On the inner prominence of the root the nutritive foramen is inserted in a groove. The hinder lateral teeth (fig. 17) are less elevated, with a pair of very sharp lateral denticles; in these the root projects strongly inwards, and also shows the cleft for the nutritive foramen.

Horizons and Localities.—Zone of *Belemnitella mucronata:* Norwich. Zone of *Micraster coranguinum:* Greenhithe and Dover, Kent. Zone of *Micraster cortestudinarium:* Purley, Surrey. Turonian zones: near Lewes and Amberley, Sussex; Cuxton and Burham, Kent; Betchworth and Whyteleafe, Surrey. Zone of *Schloenbachia varians:* Dover. Undetermined zones: Guildford, Surrey; Warminster, Wiltshire. Also Upper Greensand, Cambridge Greensand, and Gault.

2. **Scapanorhynchus subulatus** (Agassiz). Plate XLIV, figs. 18—21.

1822. *Squalus cornubicus*, G. A. Mantell (*errore*), Foss. South Downs, p. 226, pl. xxxii, fig. 1.
1843. *Lamna* (*Odontaspis*) *subulata*, L. Agassiz, Poiss. Foss., vol. iii, p. 296, pl. xxxvii *a*, figs. 5—7.
1889. *Scapanorhynchus* (*?*) *subulatus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 356.
1894. *Scapanorhynchus subulatus*, A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 196, pl. v, figs. 14, 15.
1902. *Scapanorhynchus?* (*Odontaspis*) *subulatus*, M. Leriche, Ann. Soc. Géol. Nord, vol. xxxi, p. 107, pl. iii, figs. 5—7.

Type.—Detached teeth from the Cenomanian of Saxony; Palæontological Museum, Munich.

Specific Characters.—Teeth usually smaller than in the preceding species. Dental crown smooth on both faces, not wrinkled; a single pair of acutely-pointed lateral denticles well developed on all the teeth, those of the anterior teeth more slender than those of the hinder teeth; root prominent on the inner face, with a sharp median groove.

Description of Specimens.—The typical teeth of this species are easily recognised by their smooth, shining crown, with a straight base-line externally, from the ends of which rise the prominent lateral denticles. The outer aspect of an anterior

tooth is shown in Pl. XLIV, fig. 18, while an inner view of a similar tooth (fig. 19) is added to display the groove for the nutritive foramen in the root. In a smaller tooth (fig. 20) the denticles are especially long and slender, while the root is comparatively small. In a posterior tooth (fig. 21), which is wide in proportion to its height, the pointed lateral denticles are broader.

Horizons and Localities.—Zone of *Belemnitella mucronata:* Norwich. Zone of *Marsupites:* Thanet, Kent. Zone of *Micraster coranguinum:* Gravesend, Greenhithe, and Thanet, Kent; South Croydon, Surrey; Grays, Essex. Turonian zones: near Lewes, Sussex; Whyteleafe, Surrey. Zone of *Holaster subglobosus:* Burham and Halling, Kent; Arundel, Sussex. Zone of *Schloenbachia varians:* Dover, Kent. Undetermined zones: Charing, Kent; Guildford, Surrey; Heytesbury, Wiltshire. Also Upper Greensand, Cambridge Greensand, and Gault.

Family Cestraciontidæ.

The Cretaceous Cestraciont sharks are known only by fragments. *Cestracion* itself, which ranges from the Upper Jurassic to the existing fauna, appears to be represented; while *Synechodus* is the sole survivor of the Hybodonts in the Chalk.

Genus **CESTRACION,** Cuvier.

Cestracion, G. Cuvier, Règne Animal, vol. ii, 1817, p. 129.
Drepanephorus, P. M. G. Egerton, Figs. and Descript Brit Organic Remains (Mem. Geol. Surv., 1872), dec. xiii, no. 9.

Generic Characters.—Anterior dorsal fin arising in front of the pelvic pair, posterior dorsal in front of the anal fin; each with a smooth, enamelled dorsal fin-spine, which does not bear posterior denticles. Mouth terminal, or nearly so; pterygo-quadrate cartilage in the adult directly connected with the cranium by an antorbital articulation. Anterior teeth small, numerous, cuspidate, generally with one pair of lateral denticles; lateral and postero-lateral teeth without cusps, but relatively broad and flattened, with a more or less distinct longitudinal keel and reticulate ornamentation. Shagreen fine and close; no head-spines; no large dermal hooks on the claspers of the male. Vertebral centra well developed, asterospondylic.

Type Species.—An existing shark, *Cestracion philippi.*

Remarks.—The mandible of the type species, with its characteristic dentition, is shown in Text-fig. 68. Here the two rami meet in a long symphysis, but in some species the mandibular symphysis is short (so-called *Gyropleurodus,* T. N. Gill, Proc. Acad. Nat. Sci. Philad., 1869, p. 482). In this jaw of an adult fish,

the symphysial teeth exhibit one main cusp, with not more than one pair of small lateral denticles. In very young individuals the corresponding teeth have three pairs of lateral denticles, those of the inner pair nearly as large as the main cusp.

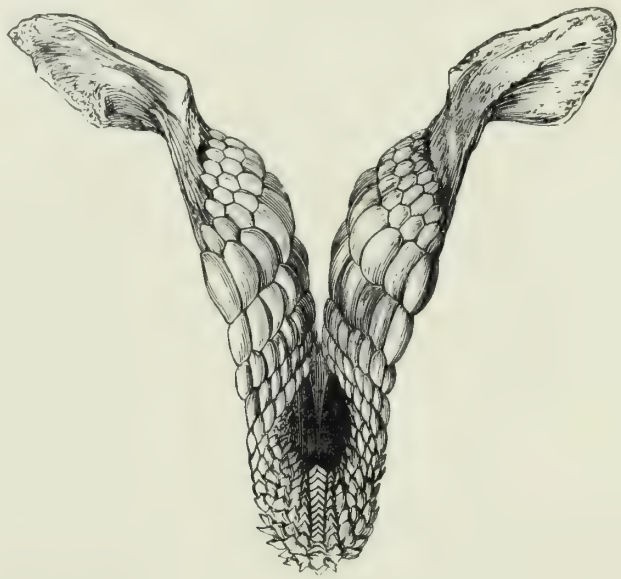


Fig. 68. *Cestracion philippi*, Cuvier; jaw with dentition, slightly reduced.—Existing.

1. **Cestracion canaliculatus**, Egerton. Plate XLV, figs. 1—5.

1822. *Balistes*, G. A. Mantell (*errore*), Foss. South Downs, p. 229, pl. xxxiii, figs. 5, 6 (in part?).
1843. *Spinax major*, L. Agassiz, Poiss. Foss., vol. iii, p. 62, pl. x *b*, figs. 8—14 (in part).
1850. *Cestracion canaliculatus*, P. M. G. Egerton, in F. Dixon, Geol. Sussex, p. 365, pl. xxxii,* fig. 8.
1850. *Acrodus cretaceus*, F. Dixon, *op. cit.*, p. 364, pl. xxx, fig. 13.
1853. *Cestracion canaliculatus*, P. M. G. Egerton, Quart. Journ. Geol. Soc., vol. ix, p. 281.
1872. *Drepanephorus canaliculatus*, P. M. G. Egerton, Figs. and Descript. Brit. Organic Remains (Mem. Geol. Surv.), dec. xiii, no. 9, pl. ix.
1883. *Cestracion canaliculatus*, C. Hasse, Neues Jahrb., vol. ii, p. 66.
1889. *Cestracion canaliculatus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 334, pl. xi, figs. 24—27.

Type.—Associated teeth from the Chalk of Kent.

Specific Characters.—Head usually attaining a length of about 9 cm. Mandibular symphysis short. Principal lateral teeth with rounded ends, scarcely, if at all, sigmoidally bent; the longitudinal keel sharp and raised into a median eminence; the rugosity of the surface prominent. Anterior teeth with a pair of broad lateral denticles; coronal surface smooth. Anterior dorsal fin-spine much arched, placed approximately over the twenty-fifth vertebra.

Description of Specimens.—The type specimen shows a few of the principal grinding teeth in natural association; and another fossil, described by Egerton (1872), in the Willett Collection, Brighton Museum, exhibits similar teeth in the

jaws, which are naturally associated with the vertebral column and dorsal fin-spines. There is also another example of the jaws with teeth in the British Museum.

The cartilages are calcified as usual in one superficial layer of compacted polygonal tesseræ. The pterygo-quadrate or upper jaw (Pl. XLV, fig. 1, *ptq.*) projects slightly in front of the mandible, but is not sufficiently well preserved to show whether or not its anterior part articulated with the cranium. The mandible (*md.*) displays its short symphysis in two specimens. In the anterior cuspidate teeth the crown is smooth on both faces, and there is a single pair of lateral denticles which varies in prominence. The crown overhangs the root on all sides, and its base-line on the outer face is arched (fig. 1 *a*). The short depressed root is triangular in shape, and its inner apex is pierced by a large nutritive foramen (fig. 2 *a*). The transition from these cuspidate teeth to the principal lateral teeth has not been clearly observed, but the latter are well shown in both the specimens already referred to. In the upper jaw of the fossil from the Willett Collection there are parts of three transverse series gradually increasing in size backwards (fig. 1 *b*); while in the same jaw of the British Museum fossil the second and third of these transverse series are followed behind by another series (fig. 2 *b*). There are thus four series of large elongated lateral teeth. They have rounded rather than truncated or bevelled ends. Their crown overhangs the depressed root on all sides and is traversed by a sharp longitudinal keel, which is raised into a median eminence. In the conspicuous reticulation of the coronal surface the main lines diverge from this central keel (fig. 1 *c*). The root is smooth on its inner face, and is often pierced by the oblique canal already described by Egerton (fig. 2 *c*). In the Willett fossil the teeth of the three series measure respectively 0·5 cm., 0·6 cm., and 0·75 cm. in length; while in the British Museum fossil the measurements are 0·5 cm., 0·65 cm., and 0·5 cm. respectively. Some detached teeth in the latter (fig. 2 *d*), measuring 0·4 cm. in length, probably correspond with those of the first series in the former specimen. There is no evidence of posterior small teeth in either specimen; but a displaced crushing tooth in front of the principal lateral teeth in the second measures only 0·3 cm. in length (fig. 2 *b*, *x*.). It may belong to the lower jaw.

The imperfect fish described by Egerton (1872) proves that the fossil drawn in Pl. XLV, fig. 3, represents part of the vertebral column with the anterior dorsal fin-spine of this species. The vertebral centra are shown to be asterospondylic, with few stout radiating plates; and a little behind the fin-spine they begin to be comparatively short and deep. Though imperfect in the middle, the fin-spine is not broken across and so exhibits its precise shape. It is hollow and much laterally compressed, with a deep base of insertion, and its exposed portion is covered with a smooth layer of ganoine. Its posterior border is longitudinally channelled, but without denticles. As already noted by Egerton,

the posterior dorsal fin-spine is less arched and somewhat smaller than that just described. Similar fin-spines, found detached, were originally named *Spinax major* by Agassiz (1843), but it is uncertain as to how many of them belong to this species, or even to *Cestracion*. Some are doubtless referable to *Synechodus*.

A few granules of shagreen are seen on the snout (Pl. XLV, fig. 1, *s*.). They are all quite smooth, and most of them are quadrangular in shape, with a small but deep, vertically-fluted base of insertion (fig. 1 *d*).

Some teeth of *Cestracion* larger than those of the typical *C. canaliculatus* are occasionally found in the lower zones of the Chalk, and seem to be distinguished by their more sigmoidally-bent shape, less rounded ends, and blunter coronal eminence. Two such specimens are shown in Pl. XLV, figs. 4, 5. They have been provisionally referred to *Cestracion rugosus*, which is known by detached teeth from the Danian of Maastricht, Holland (A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, 1889, p. 335, pl. xi, fig. 29; and Proc. Yorks. Geol. and Polyt. Soc., vol. xii, 1891, p. 67, pl. ii, fig. 8); but their identification with the Danian species is probably incorrect, and it is possible that they merely represent unusually large individuals of the species now described. There may, however, be a second species of *Cestracion* represented in the English Chalk; for comparatively stout and blunt anterior teeth are known, in which the coronal surface is rugose at the base (*Gomphodus*, Reuss: A. S. Woodward, Proc. Geol. Assoc., vol. xiii, 1894, p. 194, pl. v, figs. 9, 10).

Horizons and Localities.—Turonian zone: Malling, near Lewes. Zone of *Holaster subglobosus*: Southeram and Glynde, Sussex. Undetermined zones: near Bromley, Kent; Guildford, Surrey.

Genus **SYNECHODUS**, A. S. Woodward.

Synechodus, A. S. Woodward, Proc. Geol. Assoc., vol. x, 1888, p. 288.

Generic Characters.—Pterygo-quadrate cartilage in the adult directly connected with the cranium by a postorbital articulation. All teeth cuspidate, those at the symphysis few and with more than one pair of lateral denticles, those behind becoming extended and low-crowned, with the principal cusp and lateral denticles often reduced to small tubercles or points. Vertebral centra distinctly asterospondylic. Dorsal fin-spines probably smooth, enamelled, without posterior denticles. Shagreen fine; no cephalic spines.

Type Species.—*Synechodus dubrisiensis*, from the English Chalk.

Remarks.—This genus is most closely related to the Liassic *Palæospinax*, from which it differs especially in the higher degree of calcification of its vertebral centra. The teeth, when found isolated, have most commonly been referred to *Hybodus*, sometimes to *Acrodus*. The dorsal fin-spines have not yet been discovered

in direct association with the skeleton, but it is almost certain that they are included among those usually named *Spinax major* (see p. 216). No ribbed fin-spines have been found in the Chalk; the fragments in the Mantell Collection described as *Hybodus sulcatus* "from the Chalk of Lewes" (L. Agassiz, Poiss. Foss., vol. iii, 1837, p. 44, pl. x *b*, figs. 15, 16) being truly Wealden fossils.

1. **Synechodus dubrisiensis** (Mackie). Plate XLV, figs. 6, 7; Plate XLVI, figs. 1, 2.

1863. *Hybodus dubrisiensis*, S. J. Mackie, Geologist, vol. vi, p. 241, pl. xiii.
1886. *Hybodus (?) dubrisiensis*, A. S. Woodward, Proc. Zool. Soc., p. 218, pl. xx.
1888. *Synechodus dubrisiensis*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 288; and Geol. Mag., [3] vol. v, p. 496, woodcut.
1889. *Synechodus dubrisiensis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 327, text-fig. 12, pl. xi, figs. 17—20, pl. xii, fig. 6.
1894. *Synechodus dubrisiensis*, A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 193, text-fig. 1.

Type.—Jaws with a few teeth from the zone of *Holaster subglobosus;* British Museum.

Specific Characters.—The type species, with jaws attaining a length of about 8 cm. The continuous base of the crown in all the teeth marked by fine reticulating wrinkles, and at least the lower portion of the coronal cusps vertically striated. Supposed upper anterior teeth robust, the coronal surface prominently striated almost to the acute apex, and the comparatively small lateral denticles three or four in number; base-line of crown gently arched. Supposed lower teeth of the anterior pair minute, the main cusp slender, with two denticles on the symphysial side, one denticle on the other; following teeth with well-developed and well-separated acute lateral denticles. Hinder teeth slender and much extended, with both main cusp and lateral denticles reduced to smooth beads.

Description of Specimens.—The jaws of the type (Pl. XLV, fig. 6) are smaller than those of most specimens, evidently belonging to a young individual. With these and each of the other known jaws there are a few scattered teeth; and one fossil in the Willett Collection (Pl. XLVI, fig. 1) exhibits the whole of the dentition presumably of the mandible. In one specimen (Pl. XLVI, fig. 2) remains of the jaws are directly associated with part of the skull, vertebral column, and pectoral arch.

In all cases the cartilages are calcified only in a thin superficial layer, but this is sufficiently compact for good preservation. The shape of the jaws is thus distinguishable in several specimens. The pterygo-quadrate or upper jaw (Pl. XLV, figs. 6, 7, *ptq.*) deepens upwards at the end of its anterior third into an acute pterygo-trabecular process (*p.*); while at the end of its middle third it rises into a much higher otic process (*ot.*), which in one specimen (fig. 7) clearly bears a

facette for a postorbital articulation with the skull. The mandibular cartilage (figs. 6, 7, *md.*) is deepest just beneath the hinder end of its tooth-bearing portion, and gradually tapers to the blunt symphysis, which is short. In the hyoid arch the upper or hyomandibular element (fig. 7, *hm.*) is comparatively small and slender. The ceratohyal (fig. 7 *a*, *chy.*) is much larger and stouter, and expanded at its distal or anterior end; at one third of its length from the proximal end its lower border exhibits a prominent tuberosity (*x.*), evidently for a muscular insertion (see Proc. Zool. Soc., 1886, p. 222).

The partially scattered teeth imperfectly shown in the type specimen belong chiefly to some of the antero-lateral series, though there are also a few of the small, narrow, beaded teeth of the hindmost series. One tooth (fig. 6 *a*) seems to correspond with those of the fourth series in the well-preserved dentition shown in Pl. XLVI, fig. 1, and most of the others are easily comparable with various teeth in the same specimen. This fossil may therefore be described as exhibiting the whole of the dentition of one jaw of *S. dubrisiensis*. About 140 teeth are displayed in their natural relative positions. There are eleven series on either ramus of the jaw, each of those posteriorly placed comprising as many as eight or nine teeth, while those near the symphysis have not more than six. The base of the crown in all the teeth is marked by fine, reticulating wrinkles, and at least the lower portion of the coronal cusps is vertically striated. The low root is flattened on its attached face, though coarsely crimped along the outer border; and, at least in the anterior teeth, it projects beyond the inner face of the crown. There is no median symphysial row of teeth, and the first pair (Pl. XLVI, fig. 1, I) is extremely small. In the latter the principal coronal cusp is long and slender, its height being equal to the complete width of the tooth; and there are two small denticles in front, one behind. The teeth of series II are nearly four times as wide as those of no. I, with the principal coronal cusp still very prominent, and flanked in front and behind by three large denticles and one small point, of which those behind are the more widely spaced. The teeth of series III are very similar to those of no. II; but in the teeth of series IV and V the principal cusp rapidly becomes stouter and less elevated, and there are five denticles in front, while only three or four can be distinguished behind. In series VI to IX the size of the teeth only gradually decreases backwards, but the principal cusp becomes very short and stout, thus more resembling the lateral denticles, which are still very numerous and placed well apart. In these teeth the denticles are five or six in number, both in front and behind. In series X the teeth are only about two thirds as wide as those of no. IX, while those of series XI are still smaller by one half. In both of these the coronal prominences have become insignificant, though yet faintly indicated by a beaded contour.

The very small foremost teeth shown in the dentition just described have not hitherto been observed in any other specimens. On the other hand, some of these exhibit, in a corresponding position, comparatively large and robust striated teeth,

with several feebly marked lateral denticles on each side, and a gently arched base-line (Pl. XLV, fig. 7 *b*). Such teeth may perhaps belong to the opposing jaw; but whether this be so, or whether one type of front tooth characterises the male, the other the female, still remains to be determined.

The vertebral centra are well calcified, and those in the anterior part of the fish (Pl. XLVI, fig. 2) are slightly deeper than long. The foremost centrum (1) is indeed especially short, and appears solid in two specimens; but the other centra are clearly asterospondylic. Each half of the pectoral arch (*pct.*) consists of a single, slender cartilage, produced upwards into an attenuated extremity, and very similar in shape to the corresponding element both of *Palæospinax* and of *Hybodus*.

Traces of shagreen are often observable in the fossils. Some granules are smooth and quadrate in shape, but most are more or less oval, ridged and grooved in the direction of their long axis (Pl. XLVI, fig. 2 *a*). All have a deep base of insertion.

Horizons and Localities.—Zone of *Holaster subglobosus:* Dover and Burham, Kent; Glynde, Sussex; near Cambridge. Zone of *Schloenbachia varians:* Dover.

2. **Synechodus nitidus,** sp. nov. Plate XLVI, figs. 3, 4.

Type.—Imperfect jaws with teeth from zone of *Holaster subglobosus;* British Museum.

Specific Characters.—Somewhat larger than the type species; the large anterior teeth completely smooth, with more slender lateral denticles; the principal antero-lateral teeth also remarkably smooth, only feebly marked with fine vertical wrinkles, not reticulations, at the base of the crown, which is always continuous; hindmost teeth with low but sharply pointed cusps, also marked with vertical wrinkles, not reticulations.

Description of Specimens.—The remains of the jaws in the type specimen show that they must have attained a length of about 12 cm. With them are a few scattered teeth both from the front and from the hinder region. The large front teeth (Pl. XLVI, fig. 3 *a*) are completely smooth, with a slightly arched coronal base-line, a slender principal cusp, and not more than four well-separated, acuminate denticles on either side. Their root is coarsely crimped at the outer border, and forms a large, rounded prominence beyond the crown inwards. One of the antero-lateral teeth of the same specimen (fig. 3 *b*) has an equally slender and smooth principal cusp slightly inclined backwards; but its extended base is marked with feeble vertical wrinkles. About five lateral denticles are shown in front, but they are indistinctly divided; and there are two acuminate lateral denticles behind. An isolated tooth (fig. 4), evidently of the same species and of nearly the same position in the jaw, has the anterior extension of the crown only

finely denticulated, but three well-marked, acute denticles behind. The vertical wrinkling of the crown is here confined to the lateral portions. A posterior tooth in the type specimen (fig. 3 *c*) is more strongly marked with vertical wrinkles than the other teeth. Its principal cusp and its four or five pairs of lateral denticles are low and broad cones, each with a sharp apex.

In the type specimen the shagreen is shown to be diagonally fluted (fig. 3 *d*).

Horizons and Localities.—Zone of *Holaster subglobosus*: Snodland and Wouldham, Kent. Apparently also from the Albian of Okeford Fitzpaine, Dorset (R. B. Newton, Proc. Dorset Nat. Field Club, vol. xviii, 1897, p. 76, pl. iii, fig. 2), and from the Gault of Folkestone.

3. **Synechodus illingworthi** (Dixon). Plate XLVI, figs. 5—7.

1850. *Acrodus illingworthi*, F. Dixon, Geol. Sussex, p. 364, pl. xxx, figs. 11, 12, pl. xxxii, fig. 9
1887. *Acrodus (?) illingworthi*, A. S. Woodward, Geol. Mag., [3] vol. iv, p. 104.
1889. *Acrodus (?) illingworthi* and *Hybodus (?) sp.*, A. S. Woodward, Catal. Foss. Fishes B. M. pt. i, pp. 277, 297.
1891. *Synechodus illingworthi*, A. S. Woodward, Proc. Yorks. Geol. Polyt. Soc., vol. xii, p. 66, pl. ii, figs. 3—7.

Type.—Two associated hinder teeth from the zone of *Holaster subglobosus*.

Specific Characters.—A species known only by teeth, which sometimes attain a width of 3 cm. Main cusp and lateral denticles of the principal lateral teeth short, stout, and obtusely pointed, all closely connected and marked by fine ridges radiating from the apex. Lateral denticles tending to become obsolete in the hinder teeth, where they are indicated only by fine ridges radiating from the acute longitudinal keel of the crown.

Description of Specimens.—The type specimens are hinder teeth in which the lateral denticles are not clearly differentiated; and two other specimens figured by Dixon are the broken middle portions of similar teeth. Two more examples of such teeth, exhibiting the characteristic arrangement of the conspicuous ridges or wrinkles on the crown, are represented in Pl. XLVI, figs. 5, 6. In both of these the crown bears a small, irregular excrescence at two or three points; and in the second specimen (fig. 6) the outer and lower faces of the large root are well seen. An associated set of teeth, from which five are selected for representation in Pl. XLVI, figs. 7, 7 *a*, 7 *b*, seems to belong to the antero-lateral part of the dentition of the same species. The coronal wrinkles or ridges on these teeth are as prominent as those on the type specimens and similarly radiate from the series of apices; but they are fewer and less closely arranged, so that the enamel appears smoother. The blunt principal cusp is more elevated, and the equally blunt lateral denticles, in from four to six pairs, are well differentiated. In one specimen a single small cusp occurs as an irregular lateral excrescence.

Horizons and Localities.—Zone of *Holaster subglobosus:* Southeram, near Lewes, Sussex; Dorking, and near Guildford, Surrey. Zone of *Schloenbachia varians:* Dover, Kent.

4. **Synechodus recurvus** (Trautschold). Plate XLVI, fig. 8.

1877. *Sphenodus recurvus*, H. Trautschold, Bull. Soc. Imp. Nat. Moscou, vol. lii, p. 335, pl. v, fig. 4.
1889. *Synechodus recurvus*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 329.
1889. *Synechodus* sp., A. S. Woodward, *tom. cit.*, p. 330, pl. xii, fig. 7.

Type.—Tooth from Cenomanian of Saratov, Russia.

Specific Characters.—Somewhat larger than the type species and known only by teeth. Main cusp high and compressed, with acute lateral edges, its flattened outer face smooth or only a little wrinkled at the base, its convex inner face marked only by a few fine vertical wrinkles at the base; lateral cusps separately inserted on the root, slender, sharply pointed, and marked with fine vertical wrinkles; base-line of crown straight or gently arched; lower outer edge of root coarsely crimped.

Description of Specimens.—Two teeth from the Upper Chalk of Norwich in the British Museum (Nat. Hist.) agree so closely with typical specimens of *S. recurvus* from the Cenomanian of Russia that they probably belong to the same species. Both of them exhibit all the features noted in the above diagnosis, and the best is represented in Pl. XLVI, fig. 8. In this tooth the inner pair of lateral denticles is relatively large, bent inwards, and slightly divergent. The small outer lateral denticles are supplemented by a minute point at their base. The root is pierced by nutritive foramina, of which the largest forms a small postero-median cleft.

Horizon and Locality.—Zone of *Belemnitella mucronata:* Norwich.

Some detached teeth from the Upper Chalk of Norwich may perhaps belong to other species of *Synechodus*. One of these, presented to the British Museum by Mr. B. B. Woodward (no. P. 5846), closely resembles a tooth from the zone of *Belemnitella mucronata* at Meudon, France, described by F. Priem, Bull. Soc. Géol. France, [3] vol. xxv (1897), p. 48, pl. i, figs. 29—32. In several respects it agrees with the anterior teeth of *S. nitidus*, but differs in being marked with a few fine vertical ridges on the lateral denticles and on the inner face, while it lacks the crimped border of the root which is so conspicuous beneath the outer face in the teeth of the latter species. Its crown is excessively inclined inwards.

The specimen in the Mantell Collection from the Chalk of Lewes named *Strophodus asper* by Agassiz (Poiss. Foss., vol. iii, 1838, p. 128 *b*, pl. x *b*, figs. 1—3), is not a Cestraciont tooth but a fragment of a Crustacean.

Family NOTIDANIDÆ.

Genus **NOTIDANUS**, Cuvier.

Notidanus, G. Cuvier, Règne Animal, vol. ii, 1817, p. 128.

Generic Characters.—Principal teeth consisting of a series of compressed cusps fixed on a long base, which is not bifid; all the cusps inclined in one direction, the anterior larger than the others, with or without small denticles at its base in front. Anterior teeth of the upper jaw clustered, awl-shaped; a median symphysial series in the lower jaw. Principal teeth of the upper jaw less laterally elongated, with fewer cusps than those of the lower jaw.

Type Species.—An existing shark, *Notidanus griseus*.

Remarks.—One existing species has six pairs of gill-clefts (*Hexanchus*), the others have seven pairs (*Heptranchias*). Only one nearly complete fish is known from Cretaceous formations. It was obtained from the Chalk of Mount Lebanon, and is now in the Royal Scottish Museum, Edinburgh (*Notidanus gracilis*, J. W. Davis, Trans. Roy. Dublin Soc., [2] vol. iii, 1887, p. 470, pl. xiv, fig. 1).

1. **Notidanus microdon**, Agassiz. Plate XLVII, figs. 1—6.

1822. Tooth of *Squalus* (?), G. A. Mantell, Foss. South Downs, p. 227, pl. xxxii, fig. 22.
1843. *Notidanus microdon*, L. Agassiz, Poiss. Foss., vol. iii, p. 221, pl. xxvii, fig. 1, pl. xxxvi, figs. 1, 2.
1850. *Notidanus microdon*, F. Dixon, Geol. Sussex, pl. xxx, fig. 30.
1886. *Notidanus microdon*, A. S. Woodward, Geol. Mag., [3] vol. iii, p. 213, pl. vi, figs. 10—15.
1889. *Notidanus microdon*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. i, p. 160.
1894. *Notidanus microdon*, A. S. Woodward, Proc. Geol. Assoc., vol. xiii, p. 192, pl. v, figs. 7, 8.
1902. *Notidanus microdon*, M. Leriche, Ann. Soc. Géol. Nord, vol. xxxi, p. 102, pl. iii, figs. 1, 2.

Type.—Detached tooth from the English Chalk.

Specific Characters.—A very small species, the teeth not more than 1·5 cm. in width. Principal cusp of lower lateral teeth relatively large, sometimes slender and acutely pointed; secondary cusps not more than seven in number; anterior denticulations numerous and fine, but well marked.

Description of Specimens.—Though the teeth of this species are common in collections, they have always hitherto been found isolated, never in associated series. They exhibit nearly all the variations in shape which are characteristic of the dentition in the existing *Notidanus*, but the symphysial teeth remain unknown. Some (Pl. XLVII, fig. 1) are obviously from the front of the upper jaw, and consist only of a single large cusp, with very minute serrations at its base in front, and one or two small denticles behind. Short teeth, with a prominent principal cusp, few and large anterior serrations, and four or five posterior cusps (figs.

2, 3) may be referred with equal certainty to positions in the upper jaw somewhat further back. The elongated teeth which belong to the sides of the lower jaw—partly perhaps to the upper jaw—have fine anterior serrations and the principal cusp usually prominent (figs. 4, 5); very rarely the principal cusp is less attenuated (fig. 6). Between all these variations there are so many intermediate stages that there can be no doubt as to their belonging to one and the same dentition.

Horizons and Localities.—Zone of *Belemnitella mucronata:* Norwich. Zone of *Marsupites:* Thanet, Kent; near Salisbury, Wiltshire. Zone of *Micraster coranguinum:* Northfleet and Thanet, Kent; Haling Pit, near South Croydon, Surrey. Zone of *Holaster planus:* Borstal, near Rochester, Kent; Swaffham, Norfolk. Turonian zones: Lewes, Sussex. Zone of *Holaster subglobosus:* Glynde, Sussex; Burham, Kent; Betchworth, Surrey; Cherry Hinton, Cambridge. Zone of *Schloenbachia varians:* Burham, Kent. Undetermined zones: Brighton and Newtimber, Sussex; Guildford, Surrey; Charing, Kent. Also Cambridge Greensand.

Suborder TECTOSPONDYLI.

Family Squatinidæ.

Genus **SQUATINA**, Duméril.

Squatina, C. Duméril, Zool. Analyt., 1806, p. 102.

Generic Characters.—Body depressed and flat, with blunt snout and terminal mouth; paired fins very large, the basal part of the pectorals produced forwards, but not connected with the head; two dorsal fins on the slender tail. Teeth conical and pointed, more or less laterally extended, but without denticles; outer coronal face with a small median extension downwards over the root; root depressed, not bifid. Three or four rows of teeth simultaneously in function; arranged in widely separated transverse series. Vertebral centra depressed, more or less oval in transverse section. Shagreen in places enlarged or thickened.

Type Species.—An existing fish, *Squatina angelus.*

Remarks.—This genus ranges from the Upper Jurassic to the existing fauna. Fine specimens occur in the Kimmeridgian Lithographic Stone of Bavaria and Würtemberg, and a nearly complete skeleton is known from the Upper Cretaceous of Westphalia (*Squatina baumbergensis*, W. von der Marck, Palæontogr., vol. xxxi, 1885, p. 264, pl. xxv, figs. 1—5). Only teeth, vertebræ, and other fragments occur in the English Chalk.

1. **Squatina cranei,** A. S. Woodward. Plate XLVII, figs. 7—12.

1888. *Squatina cranei,* A. S. Woodward, Quart. Journ. Geol. Soc., vol. xliv, p. 144, pl. vii, figs. 1—6.

Type.—Imperfect head, etc., from the zone of *Holaster subglobosus:* Brighton Museum.

Specific Characters.—Imperfectly known, probably attaining a length of about 75 cm. A few rather large, oval, dermal tubercles with recurved spines, probably on the paired fins. Upper anterior teeth relatively small, and the opposing teeth of the lower jaw very narrow and slender.

Description of Specimens.—The type specimen in the Willett Collection exhibits the remains of the head described and figured, *loc. cit.* So far as they can be compared, the cartilages resemble those of the existing *Squatina.* Among the numerous scattered teeth, those from the front of the mouth are distinguishable. Those near the symphysis of the mandible (Pl. XLVII, fig. 7) are relatively high and slender, while the opposing teeth (fig. 8) attain but small dimensions. More posteriorly, both above and below, the teeth begin to exhibit the usual lateral elongation (figs. 9, 10) characteristic of the sides of the mouth. The minute granules of shagreen (fig. 11) are mostly oval in shape, having the outer enamelled surface ornamented with longitudinal or radiating ridges. The larger tubercles, like those occurring on the margins of the paired fins of the existing *Squatina,* are also of an oval form, with a slightly crenulated margin (fig. 12). From the middle of each there rises a large, backwardly directed spine, which is laterally compressed and well enamelled.

It is difficult to recognise any distinctive features in the teeth of the different species of *Squatina.* In *S. cranei,* however, the anterior lower teeth seem to be more slender than in other known forms, and the anterior upper teeth are remarkably small. In this species also the spinous dermal tubercles are relatively much larger than in the existing *Squatina angelus,* and such tubercles have not hitherto been observed in any of the extinct species.

Horizon and Locality.—Zone of *Holaster subglobosus:* Clayton, Sussex.

Teeth of *Squatina* have also been recorded from the Chalk of Lewes and Brighton (A. S. Woodward, Proc. Geol. Assoc., vol. xiii, 1894, p. 191, pl. v, figs. 2, 3), and from the zone of *Belemnitella mucronata,* near Norwich.

PLATE XXXIX.

Fig.		Page.
1.	Coprolite usually ascribed to *Macropoma*, nat. size.—Chalk; Kent. Harford Collection (B. M. no. P. 5629).	180.
2.	Part of a similar coprolite, nat. size.—Chalk; near Lewes. Mantell Collection (B. M. no. 4315).	180.
3.	*Macropoma precursor*, sp. nov.; portion of trunk, nat. size, with (3 *a*) three scales enlarged to five-halves nat. size.—Base of zone of *Holaster subglobosus;* Burham, Kent. G. E. Dibley Collection (B. M. no. P. 10810). *do'.*, anterior dorsal fin; *l.*, scales of lateral line.	182.
4.	*Elasmodectes willetti*, Newton; right side view of head and portion of trunk, nat. size, with (4 *a*) some ring-vertebræ and (4 *b*) the distal end of the dorsal fin-spine, both enlarged three times.—Zone of *Holaster subglobosus;* near Lewes. Sedgwick Museum, Cambridge. *d.*, dorsal fin-spine; *md.*, mandibular dental plate; *pct.*, pectoral arch; *pl.*, palatine dental plate; *v.*, vomerine dental plate.	191.
5.	Ditto; dorsal fin-spine, three-halves nat. size.—Chalk; Kent. Harford Collection (B. M. no. P. 5624).	192.
6.	*Elasmodectes* sp.; dorsal fin-spine above portion of pectoral arch, nat. size., with (6 *a*) portion of base of spine enlarged three times.—Zone of *Holaster subglobosus;* Clayton, Sussex. Willett Collection no. 98, Brighton Museum.	192.

A. S. Woodward. English Chalk Fishes.

Pl. XXXIX.

A. H. Searle del. et lith.

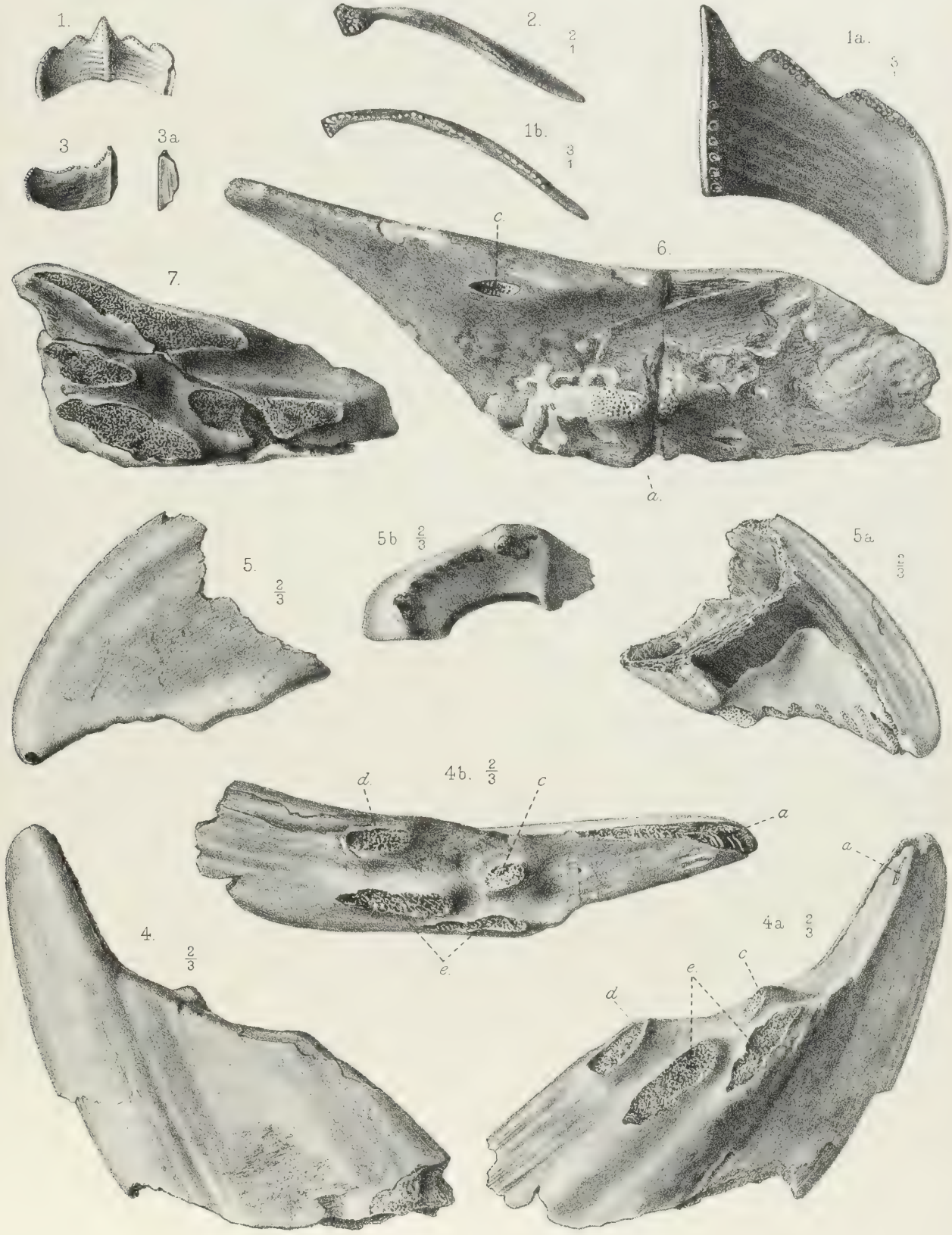
West, Newman imp.

1–3. Macropoma. 4–6. Elasmodectes.

PLATE XL.

Fig.		Page.
1.	*Elasmodectes willetti*, Newton; pair of mandibular dental plates, inner or oral view, nat. size, with that of right side enlarged three times from within (1 *a*) and from above (1 *b*). The type specimen.—Zone of *Holaster subglobosus;* Southeram, near Lewes. Willett Collection no. 148, Brighton Museum.	191.
2.	Ditto; mandibular dental plate seen from above, twice nat. size.—Zone of *Holaster subglobosus;* Burham, Kent. Mrs. Smith's Collection (B. M. no. 49024).	191.
3.	Ditto; left mandibular dental plate, inner view and (3 *a*) symphysial surface, nat. size.—Zone of *Holaster subglobosus;* Burham. G. E. Dibley Collection (B. M. no. P. 10047).	191.
4.	*Edaphodon sedgwicki* (Agassiz); left mandibular dental plate, outer, inner (4 *a*) and upper (4 *b*) views, two-thirds nat. size.—Senonian zone; Norwich. Bayfield Collection (B. M. no. P. 414). *a.*, beak with tritor; *c.*, *d.*, anterior and posterior outer tritors; *e.*, median tritor.	185.
5.	Ditto; vomerine dental plate of same specimen, outer, inner (5 *a*), and lower or oral (5 *b*) views, two-thirds nat. size.	185.
6.	*Edaphodon reedi*, Newton; right palatine dental plate, oral view, nat. size.—Zone of *Holaster subglobosus;* Glynde, Sussex. Capron Collection (B. M. no. 49727). *a.*, inner tritor; *c.*, outer tritor.	187.
7.	*Ischyodus thurmanni*, Pictet and Campiche; right palatine dental plate, oral view, showing tritors, nat. size.—Zone of *Holaster subglobosus;* Burham, Kent. Mrs. Smith's Collection (B. M. no. 49019).	189.

A.S.Woodward. English Chalk Fishes. Pl. XL.



A.H.Searle del.et lith. West, Newman imp.

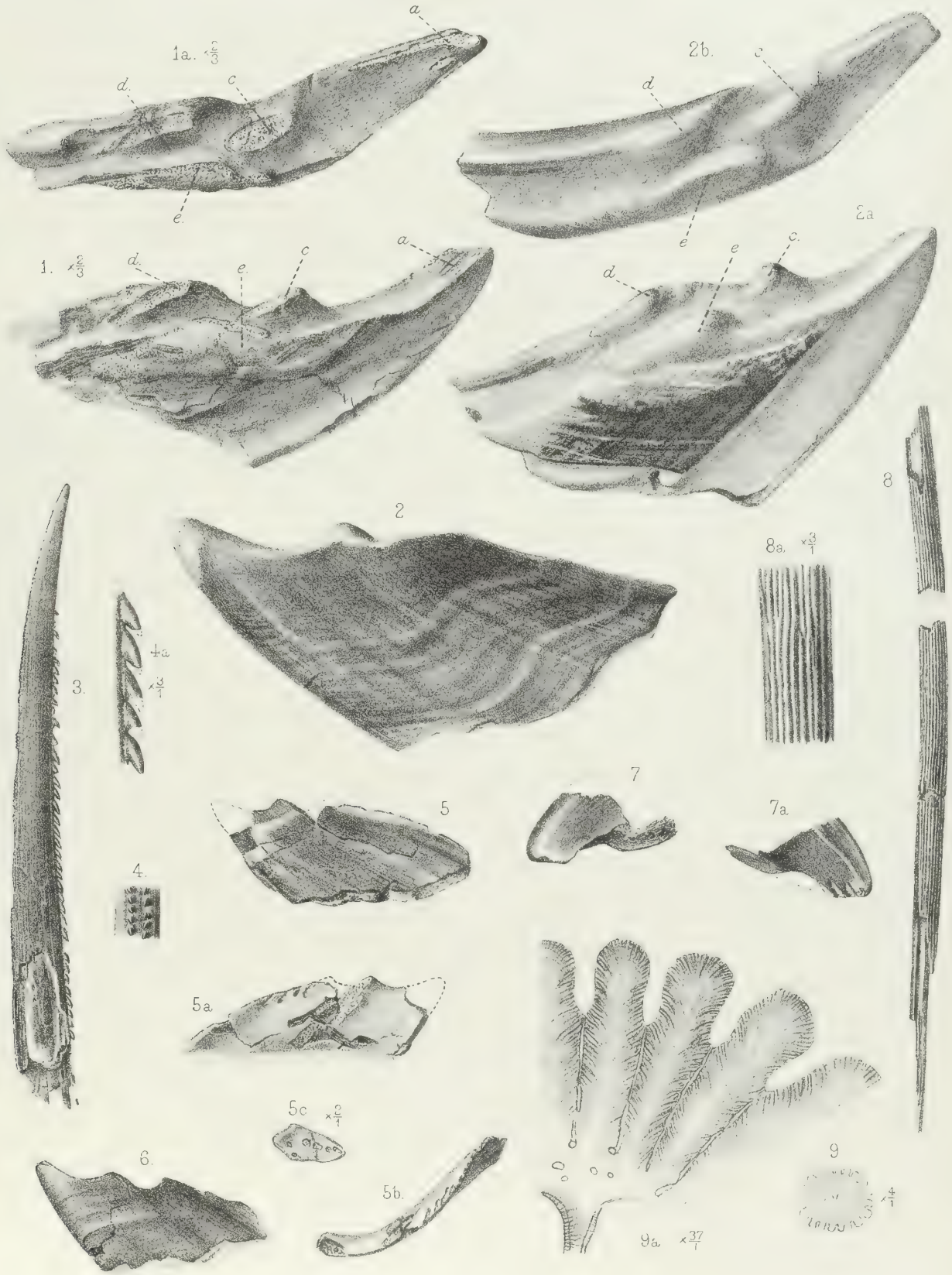
1–3. Elasmodectes. 4–6. Edaphodon. 7. Ischyodus.

PLATE XLI.

FIG. PAGE.

1. *Edaphodon mantelli* (Buckland); left mandibular dental plate, inner and (1 *a*) upper views, two-thirds nat. size.—Turonian zone; Lewes, Sussex. B. M. no. P. 5405. *a.*, beak with tritor; *c.*, *d.*, anterior and posterior outer tritors; *e.*, median tritor. 186.
2. *Edaphodon agassizi* (Buckland); left mandibular dental plate, outer, inner (2 *a*), and upper (2 *b*) views, nat. size.—Zone of *Holaster subglobosus;* Southeram, near Lewes. Capron Collection (B. M. no. 49723). Letters as in fig. 1. 187.
3. *Edaphodon* sp.; distal portion of dorsal fin-spine, side view, nat. size.—Zone of *Holaster subglobosus;* Blue Bell Hill, Burham. S. J. Hawkins Collection (B. M. no. P. 6525). 188.
4. *Edaphodon* sp.; hinder view of portion of dorsal fin-spine showing double series of denticles, nat. size, with (4 *a*) some of the denticles in side view enlarged three times.—Zone of *Holaster subglobosus;* Burham, Kent. B. M. no. 43390. 188.
5. *Ischyodus* (*?*) *incisus*, Newton; left mandibular dental plate, outer, inner (5 *a*), and upper (5 *b*) views, nat. size, with (5 *c*) broken section of beak enlarged twice to show tritors. The type specimen.—Chalk; Kent. Toulmin Smith Collection (B. M. no. 41683). 190.
6. Ditto; left mandibular dental plate, outer view, nat. size.—Zone of *Holaster subglobosus;* Burham. B. M. no. 47942. 190.
7. Ditto; left vomerine dental plate found with the preceding specimen, outer and (7 *a*) inner views, nat. size. B. M. no. 47943. 190.
8. *Cœlorhynchus cretaceus*, Dixon; imperfect spine, nat. size, with (8 *a*) portion of ornament enlarged three times. The type specimen.—Zone of *Holaster subglobosus;* Sussex. Enniskillen Collection (B. M. no. P. 3942). 193.
9. Ditto; transverse section of spine, four times nat. size, with (9 *a*) part of the same more highly magnified.—Senonian zone; Norwich. Bayfield Collection (B. M. no. 48956 *a*). 193.

A. S. Woodward, English Chalk Fishes. Pl. XLI.



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1–4. Edaphodon. 5–7. Ischyodus. 8, 9. Cœlorhynchus.

PLATE XLII.

Fig.		Page.
1, 2.	*Scyllium antiquum* (Agassiz); two teeth, outer view, five times nat. size. From the type specimen.—Zone of *Holaster subglobosus;* Burham, Kent. Enniskillen Collection (B. M. no. P. 5889).	194.
3.	Ditto; another tooth of same specimen, outer, inner (3 *a*), and side (3 *b*) views, five times nat. size.	194.
4.	Ditto; two shagreen granules of same specimen, one shown in inner and (4 *a*) side views, the other (4 *b*) in outer view only, twelve times nat. size.	194.
5, 6.	*Scyllium dubium*, A. S. Woodward; two teeth, outer and inner views respectively, eight times nat. size. From the type specimen.—Zone of *Holaster subglobosus;* Dover, Kent. Gardner Collection (B. M. no. 47288).	195.
7.	*Cantioscyllium decipiens*, A. S. Woodward; anterior portion of skeleton, lower view, nat. size. The type specimen.—Zone of *Holaster subglobosus;* Burham. Enniskillen Collection (B. M. no. P. 5890). *hy.*, hyoid arch (fragment); *l.*, labial; *md.*, mandible; *pct.*, pectoral arch; *ptq.*, pterygo-quadrate; *x.*, prominence on latter.	196.
8, 9.	Ditto; two teeth of same specimen, outer view, four times nat. size.	196.
10.	Ditto; base of tooth of same specimen, seen from attached face, four times nat. size.	196.
11.	Ditto; left ascending portion of pectoral arch of same specimen; outer view, nat. size.	196.
12–15.	*Corax pristodontus*, Agassiz; four isolated teeth, outer views, nat. size.—Zone of *Belemnitella mucronata;* Norwich. Bayfield Collection (B. M. no. 48946).	198.
16–18.	*Corax falcatus*, Agassiz; three isolated teeth, outer view, the first and third nat. size, the second enlarged one and a half times. Type specimens.—Turonian zone; Lewes. Mantell Collection (B. M. nos. 4454, 4457, 4465).	198.
19.	Ditto; tooth, outer view, nat. size.—English Chalk (B. M. no. 40544).	199.
20.	Ditto; tooth, inner view, nat. size.—Chalk; Kent. Enniskillen Collection (B. M. no. P. 2333).	199.
21.	Ditto; imperfect large tooth, inner view, nat. size. The type specimen of *Corax maximus*, Dixon.—Turonian zone; Houghton, Sussex. Dixon Collection (B. M. no. 25758).	199.
22.	Ditto; tooth, outer view, nat. size.—Chalk, Kent. Egerton Collection (B. M. no. P. 1204).	199.
23, 24.	Ditto; two isolated teeth; outer and inner views respectively, one and a half times nat. size.—Zone of *Holaster subglobosus;* Blue Bell Hill, Burham. S. J. Hawkins Collection (B. M. no. P. 6521).	199.
25.	Ditto; hinder tooth, inner view, one and a half times nat. size.—Zone of *Holaster subglobosus;* Dover. Gardner Collection (B. M. no. P. 48).	199.
26.	Ditto; tooth, inner view, nat. size.—Ibid. Gardner Collection (B. M. no. 47145).	199.
27.	Ditto; small upright tooth, outer view, one and a half times nat. size.—Chalk; Eastbourne, Sussex. Capron Collection (B. M. no. 49942).	199.
28.	Ditto; similar tooth, inner view, one and a half times nat. size.—Turonian zone; Lewes. Mantell Collection (B. M. no. 4455 *a*).	199.

A. S. Woodward, English Chalk Fishes. Pl. XLII.

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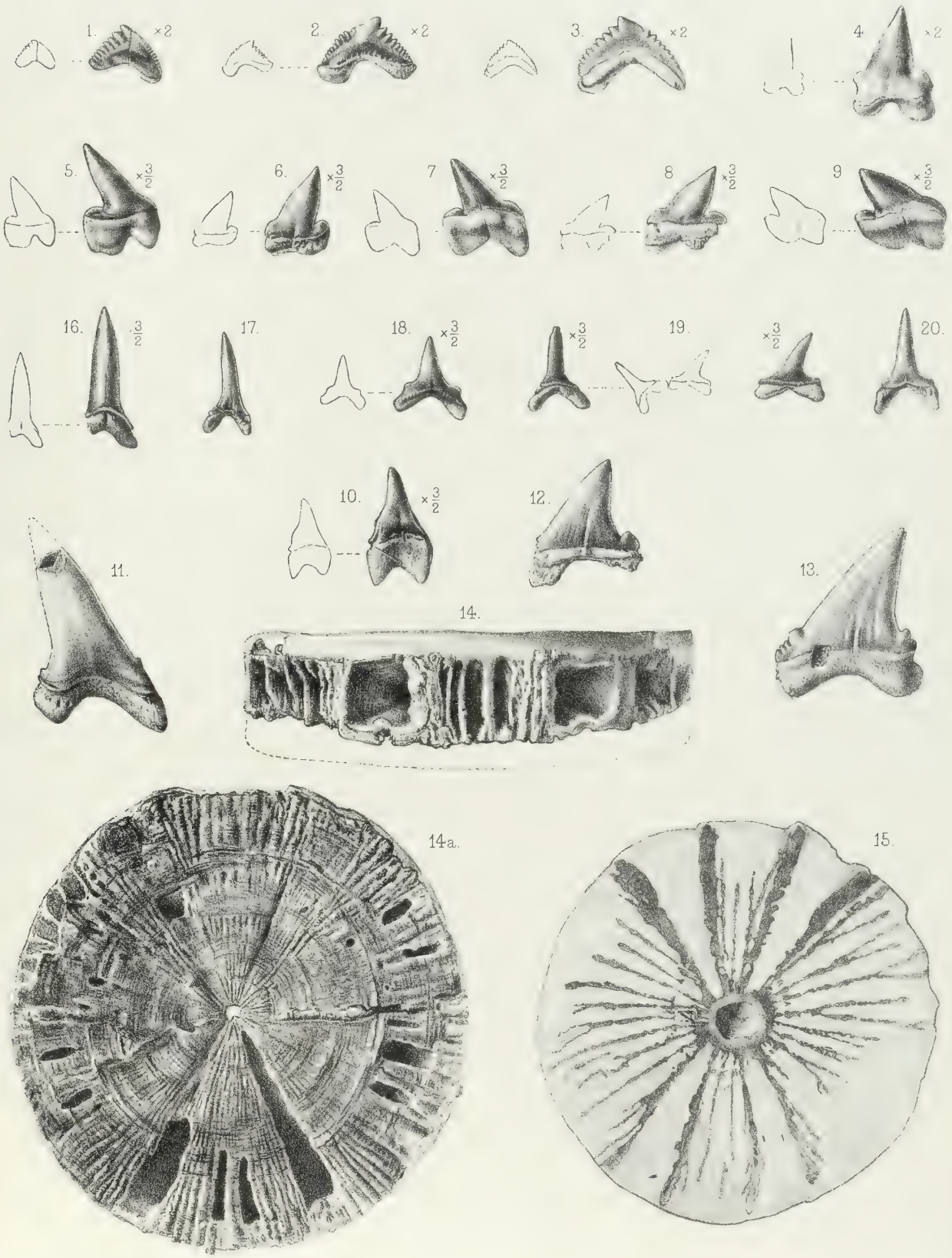
1–6. Scyllium. 7–11. Cantioscyllium. 12–28. Corax.

PLATE XLIII.

Fig.		Page.
1.	*Corax jaekeli*, A. S. Woodward; tooth, outer view, twice nat. size.—Zone of *Marsupites* (*Uintacrinus*-band); near Salisbury. Dr. H. P. Blackmore's Collection.	200.
2.	Ditto; tooth, outer view, twice nat. size.—Ibid. Dr. H. P. Blackmore's Collection.	200.
3.	Ditto; tooth, outer view, twice nat. size.—Zone of *Actinocamax quadratus*; East Harnham, Salisbury. Dr. H. P. Blackmore's Collection.	200.
4.	*Corax affinis*, Agassiz; small anterior tooth, outer view, twice nat. size.—Zone of *Belemnitella mucronata*; Norwich (B. M. no. P. 5812).	201.
5–9.	Ditto; five isolated teeth, 7 and 9 inner view, others outer view, one and a half times nat. size.—Ibid. B. M. nos. 48947, 36916, 48956 *e*, 35650, P. 5812 *a*.	201.
10.	*Oxyrhina mantelli*, Agassiz; small tooth of uncertain position, outer view, one and a half times nat. size.—Chalk; Guildford. Capron Collection (B. M. no. 49954).	203.
11.	Ditto; anterior tooth with lateral denticle, outer view, nat. size.—Chalk; Sussex. Egerton Collection (B. M. no. P. 1263).	204.
12.	Ditto; postero-lateral tooth with lateral denticle, outer view, nat. size.—Zone of *Schloenbachia varians*; Dover. Gardner Collection (B. M. no. 47255).	204.
13.	Ditto; another lateral tooth with traces of denticles, outer view, nat. size.—Chalk; Sussex. B. M. no. P. 5403.	204.
14.	Ditto; vertebral centrum, upper view and (14 *a*) vertical transverse section, nat. size, showing radiating structural plates and hollows for the cartilaginous bases of the arches.—Chalk; Sussex. Dixon Collection (B. M. no. 25939).	204.
15.	Ditto; another vertebral centrum in vertical transverse section, nat. size.—Zone of *Holaster subglobosus*; Glynde, near Lewes. Capron Collection (B. M. no. 49898).	204.
16.	*Oxyrhina angustidens*, Reuss; anterior tooth, inner view, one and a half times nat. size.—Zone of *Holaster subglobosus*; Blue Bell Hill, Burham. S. J. Hawkins Collection (B. M. no. P. 9034).	205.
17.	Ditto; anterior tooth, outer view, nat. size.—Zone of *Holaster subglobosus*; Halling, Kent. Toulmin Smith Collection (B. M. no. 41707 *b*).	205.
18.	Ditto; lateral tooth, outer view, one and a half times nat. size.—Zone of *Terebratulina gracilis*; Whyteleafe, Surrey. G. E. Dibley Collection (B. M. no. P. 10050).	205.
19.	Ditto; two associated teeth, one and a half times nat. size.—Zone of *Holaster subglobosus*; Glynde, near Lewes. Capron Collection (B. M. no. 49948).	205.
20.	Ditto; tooth, outer view, nat. size.—Zone of *Holaster subglobosus*; Blue Bell Hill, Burham. S. J. Hawkins Collection (B. M. no. P. 6522).	205.

A. S. Woodward, English Chalk Fishes. Pl. XLIII.



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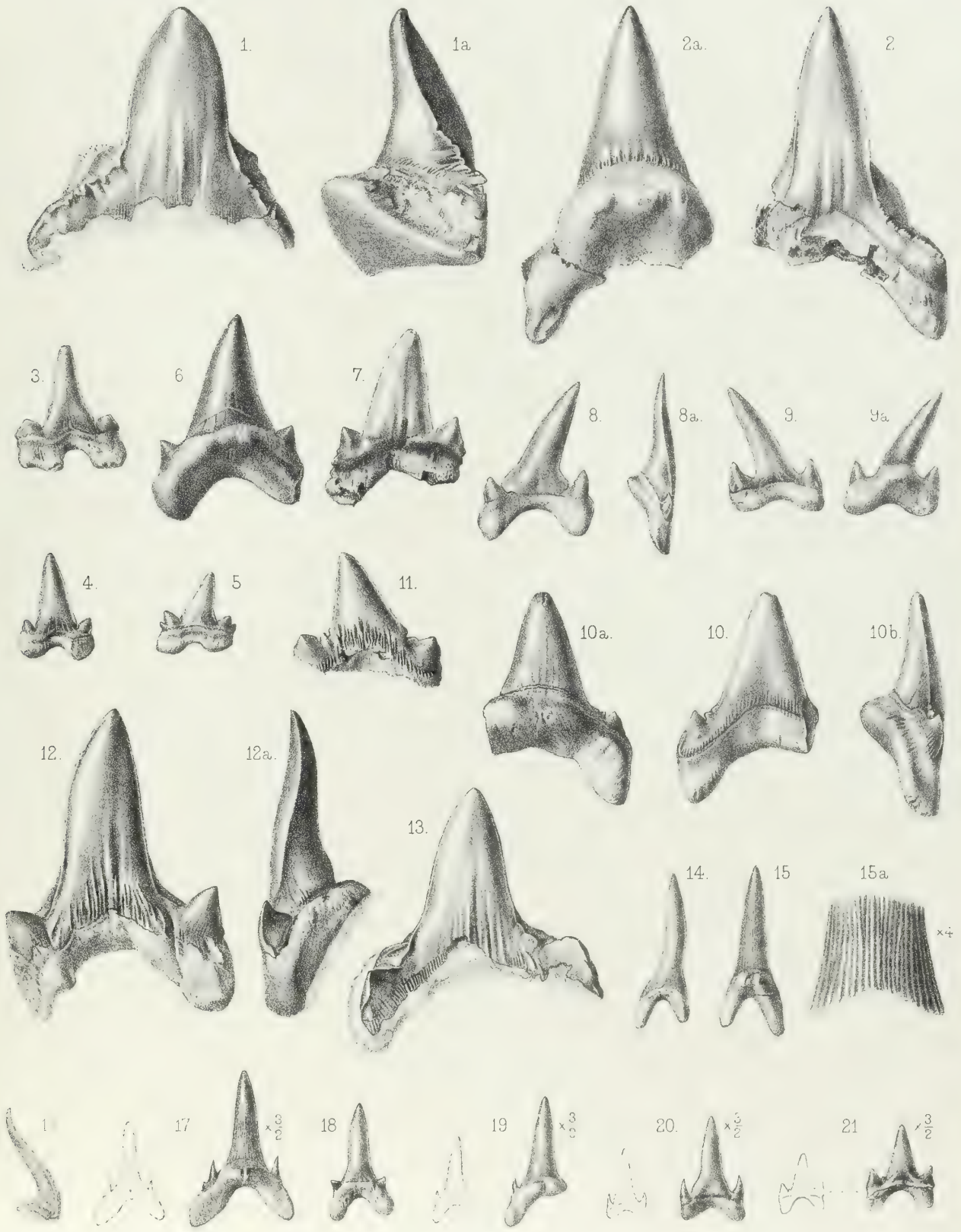
1–9. Corax. 10–20. Oxyrhina.

PLATE XLIV.

Fig.		Page.
1.	*Oxyrhina crassidens*, Dixon; tooth, outer and (1 *a*) lateral views, nat. size. The type specimen.—Turonian zone; Houghton, Sussex. Dixon Collection (B. M. no. 25823).	205.
2.	Ditto; anterior tooth, outer and (2 *a*) inner views, nat. size.—Chalk; Sussex. Dixon Collection (B. M. no. 25786).	205.
3.	*Lamna appendiculata*, Agassiz; tooth, outer view, nat. size.—Chalk; Arundel, Sussex. Capron Collection (B. M. no. 49949).	208.
4.	Ditto; tooth, outer view, nat. size.—Zone of *Belemnitella mucronata*; Norwich. Bayfield Collection (B. M. no. 48956 *a*).	208.
5.	Ditto; tooth with accessory denticles, outer view, nat. size.—Chalk; Greenhithe, Kent. Slatter Collection (B. M. no. P. 8597).	208.
6.	Ditto; stout tooth, inner view, nat. size.—Zone of *Holaster subglobosus*; Dover. B. M. no. 35544.	208.
7.	Ditto; wrinkled tooth, outer view, nat. size.—Chalk; Kent. Egerton Collection (B. M. no. P. 1280 *b*).	208.
8, 9.	*Lamna arcuata*, A. S. Woodward; two isolated teeth, one in outer and (8 *a*) lateral view, the other in outer and (9 *a*) inner view, nat. size. Fig. 8 is type specimen.—Zone of *Belemnitella mucronata*; Norwich. Bayfield Collection (B. M. no. 48956 *b*).	208.
10.	*Lamna semiplicata* (Agassiz); tooth, outer, inner (10 *a*), and lateral (10 *b*) views, nat. size.—Chalk; near Rochester, Kent. B. M. no. 43514.	209.
11.	Ditto; more posterior tooth, outer view, nat. size.—Chalk; Charing, Kent. Harris Collection (B. M. no. P. 327).	209.
12.	*Lamna sulcata* (Geinitz); anterior tooth, outer and (12 *a*) lateral views, nat. size.—Chalk; Surrey. Bowerbank Collection (B. M. no. 39054).	209.
13.	Ditto; more posterior tooth, outer view, nat. size.—Chalk; Lewes. B. M. no. P. 5402.	209.
14.	*Scapanorhynchus rhaphiodon* (Agassiz); anterior tooth, outer view, nat. size.—English Chalk. B. M. no. P. 404.	212.
15.	Ditto; anterior tooth, inner view, nat. size, with (15 *a*) portion of ornament of inner face enlarged four times.—Chalk; Kent. B. M. no. 43080.	212.
16.	Ditto; contorted anterior tooth, side view, nat. size.—Zone of *Belemnitella mucronata*; Norwich. B. M. no. P. 5892.	212.
17.	Ditto; more posterior tooth, inner view, one and a half times nat. size.—Chalk; Shalford, near Guildford. Capron Collection (B. M. no. 49952).	212.
18.	*Scapanorhynchus subulatus* (Agassiz); anterior tooth, outer view, nat. size.—Zone of *Holaster subglobosus*; Halling, Kent. Toulmin Smith Collection (B. M. no. 41707).	213.
19.	Ditto; anterior tooth, inner view, one and a half times nat. size.—English Chalk. B. M. no. P. 5758.	213.
20.	Ditto; lateral tooth, outer view, one and a half times nat. size.—Same history as fig. 18.	213.
21.	Ditto; postero-lateral tooth, outer view, one and a half times nat. size.—Chalk; Sussex. Dixon Collection (B. M. no. 25934).	213.

A. S. Woodward, English Chalk Fishes. Pl. XLIV.



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1, 2. Oxyrhina. 3–13. Lamna. 14–21. Scapanorhynchus.

PLATE XLV.

FIG. PAGE.

1. *Cestracion canaliculatus*, Egerton; lower view of imperfect jaws, nat. size, with (1 *a*) anterior tooth, outer view, three times nat. size, and (1 *b*) upper principal lateral teeth, coronal view, one enlarged three times and (1 *c*) part of its ornament enlarged five times; also (1 *d*) three dermal tubercles, one being in outer view, one from the side, and one from below, enlarged twelve times.—Turonian zone; Malling, near Lewes. Willett Collection no. 182, Brighton Museum. *md.*, mandible; *ptq.*, pterygo-quadrate (upper jaw); *s.*, shagreen: I, II, III, three series of principal lateral teeth of upper jaw. 215.

2. Ditto; anterior tooth, inner view (2 *a*), hinder principal lateral teeth and another lateral tooth (*x*), coronal view (2 *b*), the same principal lateral teeth, seen from attached face, showing oblique perforation (2 *c*, *c.*), and one anterior principal lateral tooth, coronal view (2 *d*), all three times nat. size.—Chalk; Guildford. Capron Collection (B. M. no. 49735). 215.

3. Ditto; portion of vertebral column, with anterior dorsal fin-spine.—Chalk; Sussex. B. M. no. P. 4921. 215.

4. Ditto (?); lateral tooth, coronal view, nat. size, with (4 *a*) part of its ornament enlarged five times.—Turonian zone; Lewes. Mantell Collection (B. M. no. 4166). 216.

5. Ditto (?); lateral tooth, coronal view, nat. size.—Zone of *Terebratulina gracilis;* Warlingham, Surrey. G. E. Dibley Collection (B. M. no. P. 6489). 216.

6. *Synechodus dubrisiensis* (Mackie); right side view of jaws, nat. size, with (6 *a*) an antero-lateral tooth, outer view, enlarged three times. The type specimen.—Zone of *Holaster subglobosus;* Dover. *md.*, mandible; *p.*, pterygo-trabecular process; *ptq.*, pterygo-quadrate. B. M. no. 36908. 217.

7. Ditto; jaws and hyoid arch, seen from the left side and (7 *a*) from below, nat. size, with three teeth (7 *b*, 7 *c*, 7 *d*), enlarged three times. —Chalk; Kent. Toulmin Smith Collection (B. M. no. 41675). *chy.*, ceratohyal; *hm.*, hyomandibular; *ot.*, otic process, with facette for articulation with postorbital process of skull; *x.*, tuberosity on ceratohyal; other letters as in fig. 6. 217.

A. S. Woodward, English Chalk Fishes. Pl. XLV.

A.H Searle del. et lith. West, Newman imp.

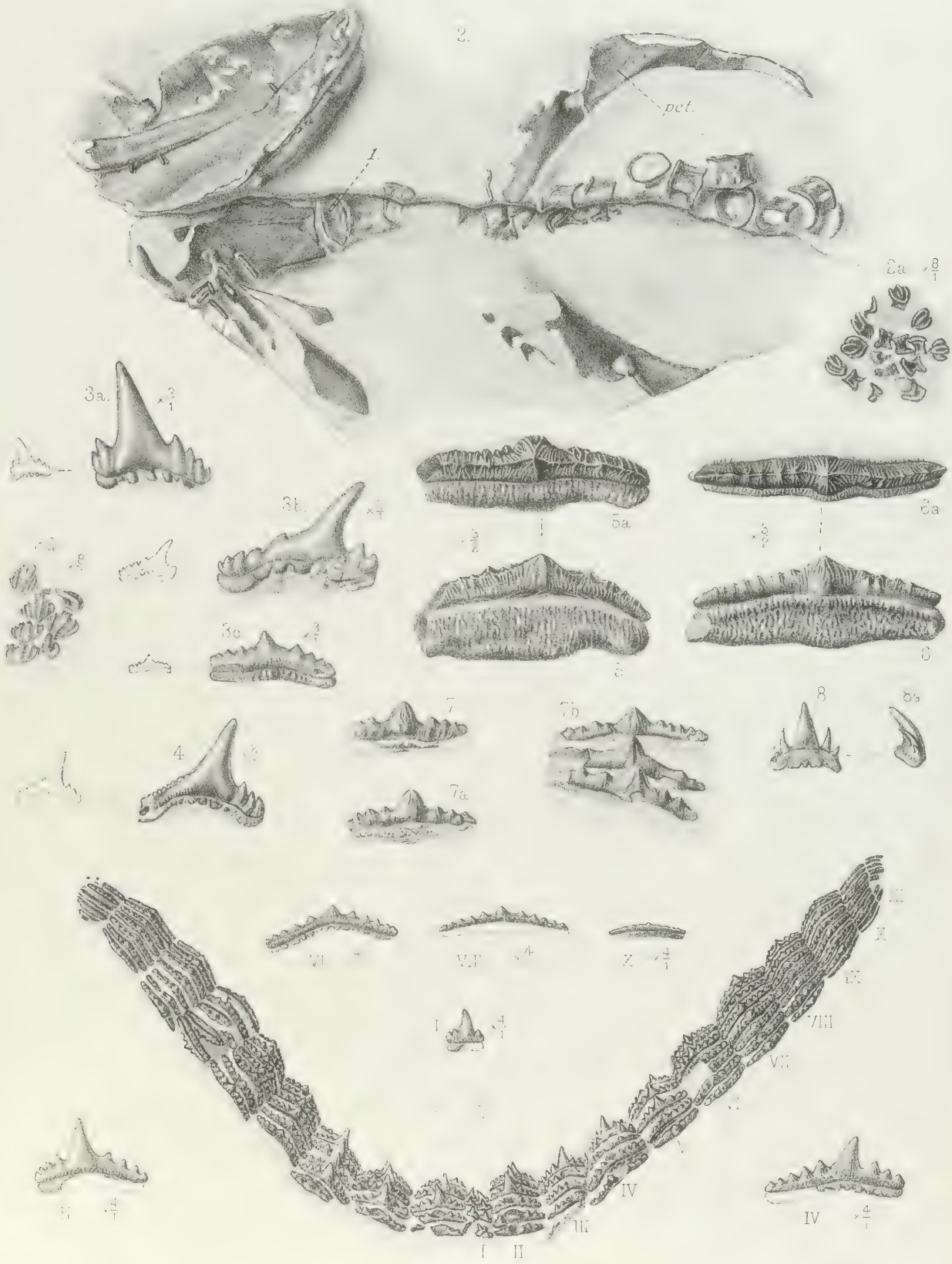
1–5. Cestracion. 6–7. Synechodus.

PLATE XLVI.

FIG. PAGE.

1. *Synechodus dubrisiensis* (Mackie); dentition of one jaw, twice nat. size, with six teeth, of the series indicated by numbers, enlarged four times.—Chalk; Sussex. Willett Collection, Brighton Museum. 218.
2. Ditto; remains of anterior part of skeleton, seen from below, nat. size. —Zone of *Holaster subglobosus;* Burham, Kent. Mrs. Smith's Collection (B. M. no. 49032). *pct.*, pectoral arch; *1*, first vertebral centrum. Also 2 *a*, shagreen, eight times nat. size, occurring on jaws from same zone at Dover; Gardner Collection (B. M. no. 47287). 219.
3. *Synechodus nitidus*, sp. nov.; teeth, three times nat. size, from different parts of jaw (3 *a*—3 *c*), with (3 *d*) shagreen enlarged eight times. The type specimen.—Zone of *Holaster subglobosus;* Snodland, Kent. Egerton Collection (B. M. no. P. 1295). 219.
4. Ditto; antero-lateral tooth, outer view, twice nat. size.—Zone of *Holaster subglobosus;* Wouldham, Kent. G. E. Dibley Collection (B. M. no. P. 10228). 219.
5. *Synechodus illingworthi* (Dixon); tooth, inner and (5 *a*) coronal views, one and a half times nat. size.—Chalk; Sussex. Egerton Collection (B. M. no. P. 2148). 220.
6. Ditto; tooth, outer and (6 *a*) coronal view, one and a half times nat. size. —Zone of *Holaster subglobosus;* Southeram, near Lewes. B. M. no. P. 5879. 220.
7. Ditto; five associated teeth, nat. size.—English Chalk. B. M. no. 45311. 220.
8. *Synechodus recurvus* (Trautschold); tooth, outer and (8 *a*) lateral views, nat. size.—Zone of *Belemnitella mucronata;* Norwich. Bayfield Collection (B. M. no. 48953). 221.

A. S. Woodward, English Chalk Fishes. Pl. XLVI.



A. H. Searle del. et lith. West, Newman imp.

Synechodus.

Palæontographical Society, 1910.

A MONOGRAPH

OF THE

CRETACEOUS LAMELLIBRANCHIA

OF

ENGLAND.

BY

HENRY WOODS, M.A.

UNIVERSITY LECTURER IN PALÆOZOOLOGY, CAMBRIDGE.

VOL. II. PART VII.

INOCERAMUS.

Pages 261—284; Plates XLV—L.

LONDON:

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Affinities.—When describing the Mollusca of the Chalk Rock in 1897 only an imperfect specimen of *C. pulchra* was available for study, and I identified it with *C. caudata* (Nilsson). Two better specimens from Norwich have now been seen, and a new figure of Nilsson's type has been published by Hennig.[1] The English form—figured by Sowerby as *Leda pulchra*—differs from the type of *C. caudata* in the relatively greater height of the anterior part of the shell, the more nearly posterior position of the umbones, and in the posterior rostrum proceeding from the level of the hinge-line instead of below it. *C. pulchra* approaches closely the specimen figured by Goldfuss[2] as *C. caudata*, and it was chiefly on account of this resemblance that I identified the English form with Nilsson's species. Stoliczka[3] and. Hennig, however, consider that Goldfuss' specimen is not an example of *C. caudata*. If all the specimens figured by foreign writers as *C. caudata* really belong to that species then it is obviously extremely variable and might well include *C. pulchra*. Without an opportunity of studying a series of foreign specimens and a larger number of English examples it seems, at present, preferable to regard *C. pulchra* as distinct from *C. caudata*. None of the English specimens shows evidence of the existence of such a long posterior beak as is present in the type of *C. caudata*.

A specimen of *Cuspidaria* from the Upper Greensand of Devizes (Plate XLIV, fig. 7) resembles some specimens of *C. pulchra* and may be provisionally referred to that species.

Type.—The type, from the "Chalk of Kent," cannot now be found.

Distribution.—Chalk Rock of Cuckhamsley, Berkshire, and Henley Park. Upper Chalk (zone of *Belemnitella mucronata*) of St. Giles' Gate and Horstead, near Norwich.

[1] 'Revis. Lamellibr. i Nilsson's Petrific. Suecana Format. Cret.' (1897), p. 62, pl. iii, fig. 28; Ravn, 'Mollusk. i Danmarks Kridtafl. I. Lamellibr.' (1902), p. 65 [133], pl. iv, fig. 24.

[2] 'Petref. Germ.,' vol. ii (1840), p. 251, pl. cli, fig. 17. Compare also Wollemann, 'Senons v. Biewende' ('Jahrb. d. k. preuss. geol. Landesanst.,' für 1900), p. 23, fig. 5; Müller, 'Mollusk. d. Untersen. v. Braunschweig u. Ilsede' (1898), p. 77, pl. x, figs. 10, 11; Wollemann, 'Fauna der Lüneburg. Kreide' (1902), p. 80.

[3] 'Palæont. Indica, Cret. Fauna S. India,' vol. iii (1870), p. 41.

Family—PERNIDÆ, *Zittel.*

(*Continued from page* 95.)

Genus—Inoceramus, *J. Sowerby*,[1] 1819.

(J. Parkinson [*ex* Sowerby MS.], 'Trans. Geol. Soc.,' ser. 1, vol. v, 1819, p. 55. J. Sowerby, 'Trans. Linn. Soc.,' vol. xiii, 1822, p. 455.)

Inoceramus neocomiensis, *d'Orbigny*, 1846. Plate XLV, figs. 1, 2.

1846.	Inoceramus neocomiensis,	*A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 503, pl. cccciii, figs. 1, 2.
1850.	—	—	*d'Orbigny.* Prodr. de Pal., vol. ii, p. 83.
1854.	—	—	*J. Morris.* Cat. Brit. Foss., ed. 2, p. 170.
1855.	—	—	*G. Cotteau.* Moll. Foss. de l'Yonne, p. 107.
1869.	—	—	*F. J. Pictet and G. Campiche.* Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 104.
1900.	—	—	*A. Wollemann.* Die Bivalv. u. Gastrop. d. deutsch. u. holländ. Neocoms, p. 60.
? 1905.	—	—	*E. Harbort.* Die Fauna d. Schaumburg-Lippe'schen Kreidemulde, p. 44, pl. ix, figs. 4–6.

Description.—Shell inequivalve, very inequilateral, a little higher than long. Valves convex, with flattened sides, and the posterior part compressed. Anterior margin nearly straight; posterior and ventral margins rounded. Posterior margin forming an obtuse angle with the hinge-line. Anterior part nearly perpendicular to the plane of the valves and excavated near the umbones. Umbones terminal, curved inwards and forwards. Hinge-line equal to more than half the height of the shell, and making an angle of about 100° with the anterior margin.

Ornamentation consists of narrow, regular, concentric ribs with an unsymmetrical curvature; the interspaces are broad and regularly concave.

[1] In rearranging the collection of *Inocerami* in the British Museum, Mr. R. B. Newton and Mr. C. D. Sherborn have found several type-specimens, the existence of which had not been previously recognised; this discovery has greatly facilitated my work. I am also indebted to Mr. Newton and Mr. Sherborn for assistance in selecting specimens for figuring. I wish to thank Mr. C. P. Chatwin for information respecting the zonal distribution of the species of *Inoceramus* in the Chalk and for other assistance. Dr. Blackmore, Dr. Rowe, and Mr. G. E. Dibley have helped by the loan of numerous specimens from their collections.

Affinities.—See *I. anglicus* (p. 264).

I. neocomiensis appears to be allied to *I. Ewaldi*, Schlüter,[1] of which only one figure has yet been published. The differences seen are in the greater relative height, the more inequilateral form, and the greater convexity of the curve of the ribs of *I. neocomiensis*.[2]

Remarks.—This species was first recorded in England by Fitton. Only a few specimens have been seen; they agree fairly well with d'Orbigny's figure, but the ribs appear to be better defined, and usually the posterior ear-like part is less distinctly limited. The English specimens are not sufficient to show whether the inequality of the valves is as great as in d'Orbigny's figure.

Type.—Prof. Boule informs me that d'Orbigny's figures are restorations based on two specimens from the Barremian of Bettancourt. The types are in the Natural History Museum, Paris.

Distribution.—Lower Greensand (Fitton's Bed 13) of Atherfield. Hythe Beds of Lympne. Lower Greensand of Nutfield.

INOCERAMUS, sp.

A few specimens of *Inoceramus*, not sufficiently perfect for description, have been found in the Speeton Clay (zone of *Belemnites lateralis*) and in the Spilsby Sandstone of Holton and Acre House.

INOCERAMUS SALOMONI, *d'Orbigny*, 1850. Plate XLV, figs. 3—7.

1850.	INOCERAMUS SALOMONI,	*A. d'Orbigny.*	Prodr. de Pal., vol. ii, p. 139.
1853.	—	—	*F. J. Pictet and W. Roux.* Moll. Foss. Grès verts de Genève, p. 501, pl. xlii, fig. 3.
1855.	—	—	*G. Cotteau.* Moll. Foss. de l'Yonne, p. 107.
1869.	—	—	*F. J. Pictet and G. Campiche.* Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 109, pl. clx, figs. 5—8.

Description.—Left valve inflated, subquadrate, very inequilateral. Length and height nearly equal. Anterior half of valve very convex; posterior half compressed. Anterior end of valve more or less nearly perpendicular to the plane between the valves, and concave near the umbo. Umbo anterior, prominent, pointed, incurved.

[1] See footnote on p. 267.

[2] Compare also forms described by Schmidt as allied to *I. neocomiensis*, 'Mém. Acad. Imp. Sci. St. Pétersb.,' ser. 7, vol. xviii (1872), pp. 155—161, pl. ii, fig. 8, pl. iii, figs. 6—9.

A broad, usually shallow sulcus extends from below the umbo to the ventral margin, where it produces a slight sinuosity; usually the sulcus starts at some distance from the umbo, and may consequently be absent in small specimens. Ornamentation consists of small, narrow, somewhat irregular concentric ribs, separated by broad, shallow, concave interspaces.

Affinities.—This species is related to *I. concentricus*, Parkinson, but is distinguished by its subquadrate outline, by the length and height being nearly equal, and by the presence of the sulcus.

Remarks.—All the specimens seen are internal casts of left valves. The examples figured by Pictet and Roux and by Pictet and Campiche are also left valves.

Type.—D'Orbigny's specimens came from the Albian of Novion, Clar, Géraudot, and Saint Florentin.

Distribution.—*Mammillatus* bed of Copt Point, Folkestone.

INOCERAMUS ANGLICUS, sp. nov. Plate XLV, figs. 8—10. Text-fig. 29.

1822. INOCERAMUS, sp., *G. Mantell.* Foss. S. Downs, p. 96, pl. xix, fig. 20.
1859. — CRISPII, *T. Wiltshire.* The Red Chalk of England (Geol. Assoc.), p. 16, pl. i, fig. 4.
1875. — CONCENTRICUS, *A. J. Jukes-Browne.* Quart. Journ. Geol. Soc., vol. xxxi, p. 299.

Description.—Shell equivalve or nearly equivalve, very inequilateral. Anterior part of shell convex, the convexity decreasing with age; posterior part compressed, flattened. Anterior slope of valves steep. Anterior margin moderately convex; ventral margin very convex; posterior margin curved, and forming an obtuse angle with the hinge-line. Length of hinge equal to rather more than a third of the height of the shell. Umbones nearly terminal, with a small anterior curvature.

Ornamentation consists of strong, regular, concentric ribs, which have a subsymmetrical curvature, and become less distinct on the posterior flattened part of the shell. The ribs have rounded summits, and are separated by broad rounded furrows with symmetrical slopes. Some of the ribs bifurcate, some may be discontinuous, or new ribs may be intercalated.

Affinities.—The equal size of the valves, the greater convexity of the curve of the ribs, the convex form of the anterior margin, and the outward slope of the anterior part of the valves distinguish this species from *I. neocomiensis*, d'Orbigny (p. 262).

I. anglicus also resembles *I. Ewaldi*, Schlüter,[1] but is relatively higher, more inequilateral, and the ribs are more strongly curved.

Remarks.—This species has been usually identified as *I. concentricus*, Parkinson, but the equal size of the valves and other characters readily distinguish it from

Fig. 29.—*Inoceramus anglicus*, sp. nov. Red Limestone, Hunstanton. Sedgwick Museum, Cambridge. Part of right valve. Natural size.

that species. An example from Hunstanton was figured by Wiltshire as *I. Crispii* (= *Crippsi*), Mantell.

Distribution.—Red Limestone of Hunstanton. Gault of Folkestone. Cambridge Greensand (derived from the Gault). Marl in the Gault of Roydon, West Norfolk. Upper Greensand of Haldon, the Isle of Wight, and Devizes.

Inoceramus concentricus, *Parkinson*, 1819. Plate XLV, fig. 11; Plate XLVI, figs. 1—10; Plate XLVII, figs. 1, 2.

1819.	Inoceramus concentricus,	*J. Parkinson.*	Trans. Geol. Soc., ser. 1, vol. v, p. 58, pl. i, fig. 4.
1821.	—	*J. Sowerby.*	Min. Conch., vol. iii, p. 183, pl. cccv, figs. 1—6.
1822.	—	*G. Mantell.*	Foss. S. Downs, p. 95, pl. xix, figs. 15, 19.
—	—	*A. Brongniart* in *Cuvier.*	Ossemens Foss., vol. ii, pt. 2, pp. 333, 336, 609, pl. vi, fig. 11.
1828.	— gryphæoides,	*J. de C. Sowerby.*	Min. Conch, vol. vi, p. 161, pl. dlxxxiv, fig. 1.

[1] See footnote on p. 267.

1833.	Catillus pyriformis,	*H. Michelin.*	Magasin de Zoologie, iii, Classe 5, pl. xxxii.
1836.	Inoceramus concentricus,	*A. Goldfuss.*	Petref. Germ., vol. ii, p. 111, pl. cix, figs. 8*a*, *b*, *c*, (non 8*d*, *e*, *f*).
? 1842.	—	*P. Matheron.*	Catal. Foss. des Bouches-du-Rhone, p 173.
1846.	—	*A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 506, pl. cccciv.
—	—	*A. Leymerie.*	Statist. geol. et min. de l'Aube, Atlas, pl. v, fig. 12.
1850.	—	*H. B. Geinitz.*	Das Quadersandst. oder Kreidegeb. in Deutschland, p. 174.
—	—	*A. d'Orbigny.*	Prodr. de Pal., vol. ii, p. 138.
1853.	—	*F. J. Pictet and W. Roux.*	Moll. Foss. Grès verts de Genève, p. 500, pl. xlii, fig. 2.
1854.	—	*J. Morris.*	Cat. Brit. Foss., ed. 2, p. 169.
—	—	gryphæoides, *J. Morris.*	Ibid., p. 169.
1855.	—	concentricus, *G. Cotteau.*	Moll. Foss. de l'Yonne, p. 107.
1869.	—	*F. J. Pictet and G. Campiche.*	Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 107.
1876.	—	*J. F. Whiteaves.*	Mesozoic Fossils (Geol. Surv. Canada), vol. i, pp. 79, 241.
1877.	—	*C. Schlüter.*	Palæontographica, vol. xxiv, p. 255.
—	—	*G. Böhm.*	Zeitschr. d. deutsch. geol. Gesellsch., vol. xxix, p. 238.
1897.	—	*R. B. Newton.*	Proc. Dorset Nat. Hist. and Antiq. Field Club, vol. xviii, p. 88, pl. iii, fig. 12.
1906.	—	*A. Wollemann.*	Jahrb. d. k. preuss. geol. Landesanst. für 1906, vol. xxvii, p. 271.
Non 1837.	—	*G. Fischer de Waldheim.*	Oryctogr. de Moscou, p. 177, pl. xx, figs. 1—3. (= *Aucella Keyserlingiana*, Trautschold).
1841.	—	*F. A. Römer.*	Die Verstein d. nord-deutsch. Kreidegeb., p. 61.
1845.	—	*E. Forbes.*	Quart. Journ. Geol. Soc., vol. i, p. 247 (*I. neocomiensis*, d'Orb.)
— 1846.	—	*A. E. Reuss.*	Die Verstein. der böhm. Kreideformat., pt. 2, p. 24.
— 1847.	—	*J. Müller.*	Petref. der Aachen. Kreidef., pt. 1, p. 30.

Non 1875. Inoceramus concentricus, *A. J. Jukes-Browne*. Quart. Journ. Geol. Soc., vol. xxxi, p. 299.

Description.—Shell more or less ovate, much higher than long, very inequilateral and inequivalve. Anterior part of valves flattened or concave, often more or less nearly perpendicular to the plane between the valves. Posterior part of the valves somewhat expanded and less convex than the part below the umbones. Postero-dorsal part forming a small wing. Left valve very convex, with a high, narrow, pointed, terminal umbo which is considerably incurved and bends forwards. Right valve considerably less convex than the left valve, with a small, terminal umbo curved forwards but only slightly inwards. Hinge-line less than half the height of the shell.

When the shell is perfect the surface is nearly smooth except for numerous regular growth-rings. When the outer layer of the shell is wanting concentric undulations or ribs having an unsymmetrical curvature are seen, and are separated by concave furrows.

Affinities.—*I. concentricus* has been compared by Wollemann with *I. Ewaldi*, Schlüter,[1] but the prominent umbo and other characters readily distinguish it from that species. See also *I. concentricus* var. *subsulcatus*, and *I. sulcatus* (below).

Remarks.—Whilst the left valve in the specimens from the Blackdown Greensand agrees closely with that of specimens found in the Gault, the right valve in many (but not all) cases is relatively more convex, especially between the umbo and the postero-ventral extremity, and the ribs are more sharply curved. A similar modification is seen in the examples from the Red Limestone of Hunstanton. There seems no reason for regarding the specimens with these characters as forming more than a local variety dependent on the fact that they lived under conditions different from those which prevailed where the Gault was deposited.

I. gryphæoides, Sowerby, was founded on an internal cast of *I. concentricus* from the Upper Greensand; in such casts the ribs are more prominent than on the surface of the shell itself.

All the examples from the Cambridge Greensand which have been recorded as *I. concentricus* appear to belong to *I. anglicus* (p. 264).

Types.—The type, which came from the Gault of Folkestone, cannot now be found. The specimens from the same locality figured by Sowerby and by Mantell, and the type of *I. gryphæoides* from the Upper Greensand near Lyme Regis, are in the British Museum.

Distribution.—In all zones of the Gault of Folkestone. Gault of Aylesford,

[1] 'Monatsber. d. k. preuss. Akad. Wissensch., Berlin' (1860), p. 345. Schlüter, 'Palæontographica,' vol. xxiv (1877), p. 255. Wollemann, "Bivalv. u. Gastrop. d. norddeutsch. Gaults" ('Jahrb. d. k. preuss. geol. Landesanst.,' vol. xxvii, 1906), p. 272, pl. vi, fig. 9.

Dunton Green (Kent), Black Ven, and Okeford Fitzpaine. Upper Greensand (zone of *Schlænbachia rostrata*) of Blackdown, Sidmouth, Lyme Regis, and Potterne near Devizes. Limestone in the Gault of West Bilney, Roydon, and Grimston (West Norfolk). Red Limestone of Hunstanton.

INOCERAMUS CONCENTRICUS var. SUBSULCATUS, *Wiltshire*, 1869. Plate XLVII, figs. 3—14.

1853. INOCERAMUS SULCATUS, *F. J. Pictet and W. Roux.* Moll. Foss. Grès verts de Genève, p. 499, pl. xlii, figs. 1 *d*, *e*, *f*.

1869. — SUBSULCATUS, *T. Wiltshire.* Quart. Journ. Geol. Soc., vol. xxv, pp. 188, 190.

1879. — — *F. G. H. Price.* The Gault, p. 54.

In the lowest zone of the Upper Gault there occur forms of *Inoceramus* which differ from *I. concentricus* only in the fact that radial plications are more or less extensively developed. In these forms every stage can be traced between *I. concentricus* without plications into forms in which the plications are almost as complete as in *I. sulcatus*. A specimen, which differs from *I. concentricus* only in the occurrence of one shallow plication, is shown in fig. 3 (Plate XLVII); others are similar, but possess two or three plications (Plate XLVII, figs. 4, 5). In most cases the early part of the shell agrees entirely with *I. concentricus*; but the duration of this stage varies considerably in different individuals, and sooner or later either a few or many plications are developed. When the plications are numerous and start from near the umbo the shell closely resembles *I. sulcatus*, but may usually be distinguished by the rounded (instead of angular) form of the plications, and by the presence of concentric ribs. For these forms, which characterise a definite horizon in the Gault, it will be convenient to adopt as a varietal designation the name *subsulcatus*, given by Wiltshire in 1869.

From a study of many forms of this variety it seems evident that *I. sulcatus* has been derived from *I. concentricus* by the gradual development of plications, and this view is in accordance with stratigraphical distribution, since *I. concentricus* is the earlier of the two species, being found throughout the Gault, whilst *I. sulcatus* occurs in the upper part of the Gault only.

If *I. sulcatus* has been derived from *I. concentricus*, then it is clearly more nearly related to that than to any other species of *Inoceramus*, and cannot therefore be placed in a separate genus or sub-genus (*Actinoceramus*), as was proposed by Meek.[1] Further, in the early stages of the variety *subsulcatus* the shell is a typical

[1] 'Check List Cret. Foss. N. Amer.' ('Smithson. Miscell. Coll.,' No. 177, 1864), p. 32. Stoliczka, 'Cret. Fauna S. India,' vol. iii (1871), p. 393. Meek and Hayden, 'Invert. Cret. Tert. Foss. U. Missouri' (1876), p. 39.

Inoceramus, but subsequently it possesses the characters of *Actinoceramus*. Also it appears that a somewhat similar plication has originated independently in *I. Salomoni* (p. 263), and probably too in *I. radians*, Schlüter,[1] and *I. fasciatus*, Müller.[2]

Pictet and Roux regarded *subsulcatus* as a variety of *I. sulcatus* in which the number of plications had decreased; the stratigraphical distribution and also the evidence of the extensive series of specimens of *subsulcatus* which has now been obtained are opposed to this view.

Distribution.—Lowest zone of the Upper Gault of Folkestone. Upper Greensand of Blackdown. Red Limestone of Hunstanton.

INOCERAMUS SULCATUS, *Parkinson*, 1819. Plate XLVII, figs. 15—20.

1819.	INOCERAMUS SULCATUS,	*J. Parkinson.*	Trans. Geol. Soc., ser. 1, vol. v, p. 59, pl. i, fig. 5.
1821.	—	—	*J. Sowerby.* Min. Conch., vol. iii, p. 184, pl. cccvi, figs. 1—7.
1822.	—	—	*G. Mantell.* Foss. S. Downs, p. 95, pl. xix, fig. 16.
—	—	—	*A. Brongniart* in *Cuvier.* Ossemens Foss., vol. ii, pt. ii, pp. 333, 336, pl. vi, fig. 12.
1836.	—	—	*A. Goldfuss.* Petref. Germ., vol. ii, p. 112, pl. cx, fig. 1.
1837.	—	—	*W. Hisinger.* Lethæa Suecica, p. 56, pl. xvii, fig. 9.
1846.	—	—	*A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 504, pl. cccciii, figs. 3—5.
1850.	—	—	*A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 139.
1853.	—	—	*F. J. Pictet and W. Roux.* Moll. Foss. Grès verts de Genève, p. 499, pl. xlii, figs. 1*a–c* (not *d–f*).
1854.	—	—	*J. Morris.* Cat. Brit. Foss., ed. 2, p. 170.
1855.	—	—	*G. Cotteau.* Moll. Foss. de l'Yonne, p. 107.
1864.	ACTINOCERAMUS SULCATUS,	*F. B. Meek.*	Check List Cret. Foss. N. Amer. (Smithson. Miscell. Coll., No. 177), p. 32.
1869.	INOCERAMUS SULCATUS,	*F. J. Pictet and G. Campiche.*	Foss. Terr. Crét. Ste. Croix (Matér. Pal. Suisse, ser. 5), p. 105.
1875.	—	—	*A. J. Jukes-Browne.* Quart. Journ. Geol. Soc., vol. xxxi, p. 298.
1877.	—	—	*C. Schlüter.* Palæontographica, vol. xxiv, p. 256.
1884.	—	(ACTINOCERAMUS) SULCATUS,	*J. F. Whiteaves.* Mesozoic Fossils, vol. i (Geol. Surv. Canada), p. 241, pl. xxxii, fig. 3.

[1] 'Palæontographica,' vol. xxiv (1877), p. 270, pl. iii, fig. 2.

[2] 'Jahrb. d. k. preuss. geol. Landesanst. für' 1887 (1888), p. 416, pl. xviii, fig. 3.

1906. Inoceramus sulcatus, *A. Wollemann.* Jahrb. d. k. preuss. geol. Landesanst. für 1906, vol. xxvii, p. 273, pl. vi, fig. 10.

Non 1827. — — *S. Nilsson.* Petrif. Suecana, p. 18.

Description.—Shell more or less ovate, much higher than long, very inequilateral, more or less considerably inequivalve. Anterior part of valves flattened

Fig. 30.—*Inoceramus*, sp. Gault, Folkestone. Sedgwick Museum, Cambridge. Internal cast of right valve. × $\frac{4}{5}$.

or concave. Posterior part somewhat expanded and less convex than the part below the umbones. Left valve very convex, with a high, narrow, pointed anterior umbo which is considerably incurved and bends forwards. Right valve rather less convex than the left valve, with a smaller umbo which bends forwards and slightly inwards.

Ornamentation consists of strong angular radial ridges (plications), usually from eight to ten on each valve, which are often unequal in size and are separated

by deep furrows. The ridges are often at unequal distances from one another; some of them start from the umbo, others may be intercalated or may arise by bifurcation. Fine concentric lines cover the shell and are folded where they cross the ridges and furrows.

Affinities.—Although the radial plications give a distinctive appearance to this species, yet the form of the shell closely resembles that of *I. concentricus*, the main difference being that in the former the difference in the convexity of the two valves is usually less marked than in the latter.

Types.—The type, from the Gault of Folkestone, is in the British Museum. The specimens from near Lewes, Folkestone (except figs. 1 and 2), and Clophill figured by Sowerby, and the specimens figured by Mantell are in the British Museum.

Distribution.—Gault of Folkestone, Aylesford, Ringmer, Eastbourne, the Isle of Wight, and Leighton Buzzard. Upper Greensand (zone of *Schlœnbachia rostrata*) of Blackdown, Sidmouth, Black Ven, and Lulworth. Red Limestone of Hunstanton, South Willingham (Lincolnshire), and Speeton.

INOCERAMUS, sp. Text-fig. 30.

Specimens of a large, slightly convex *Inoceramus* are found in the Gault of Folkestone and the Upper Greensand of Potterne (Devizes) and the Isle of Wight, but are not sufficiently perfect for determination. The umbones are terminal, and the hinge-line is nearly at right angles to the anterior margin. The anterior parts of the valves slope steeply to the margin. Small and rather distant concentric ribs are present. This form shows some resemblance to *I. pictus* (p. 279), but is less convex, and possesses fewer ribs.

INOCERAMUS TENUIS, *Mantell*, 1822. Plate XLVIII, fig. 1. Text-figs. 31, 32.

1822. INOCERAMUS TENUIS, *G. Mantell.* Foss. S. Downs, p. 132.
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 170.
? 1859. — — *T. Wiltshire.* Red Chalk of England (Geol. Assoc.), p. 16, pl. i, fig. 5.
1866. PERNA LISSA, *H. G. Seeley.* Ann. Mag. Nat. Hist., ser. 3, vol. xvii, p. 178.

Non 1841. INOCERAMUS TENUIS? *F. A. Römer.* Die Verstein. d. nord-deutsch. Kreidegeb., p. 62, pl. viii, fig. 11.

Description.—Shell inequivalve, very inequilateral, convex; postero-dorsal part compressed; antero-dorsal part excavated and more or less nearly perpen-

dicular to the plane of the valves; height greater than length. Hinge-line equal to about two-thirds of the height of the shell. Ventral margin very convex; posterior margin forming an obtuse angle with the hinge-line. Umbones terminal, curved inwards and forwards, the left umbo larger and more prominent than the right. Surface smooth, except for growth-rings.

Affinities.—*I. tenuis* resembles *I. concentricus*, but the left umbo is less

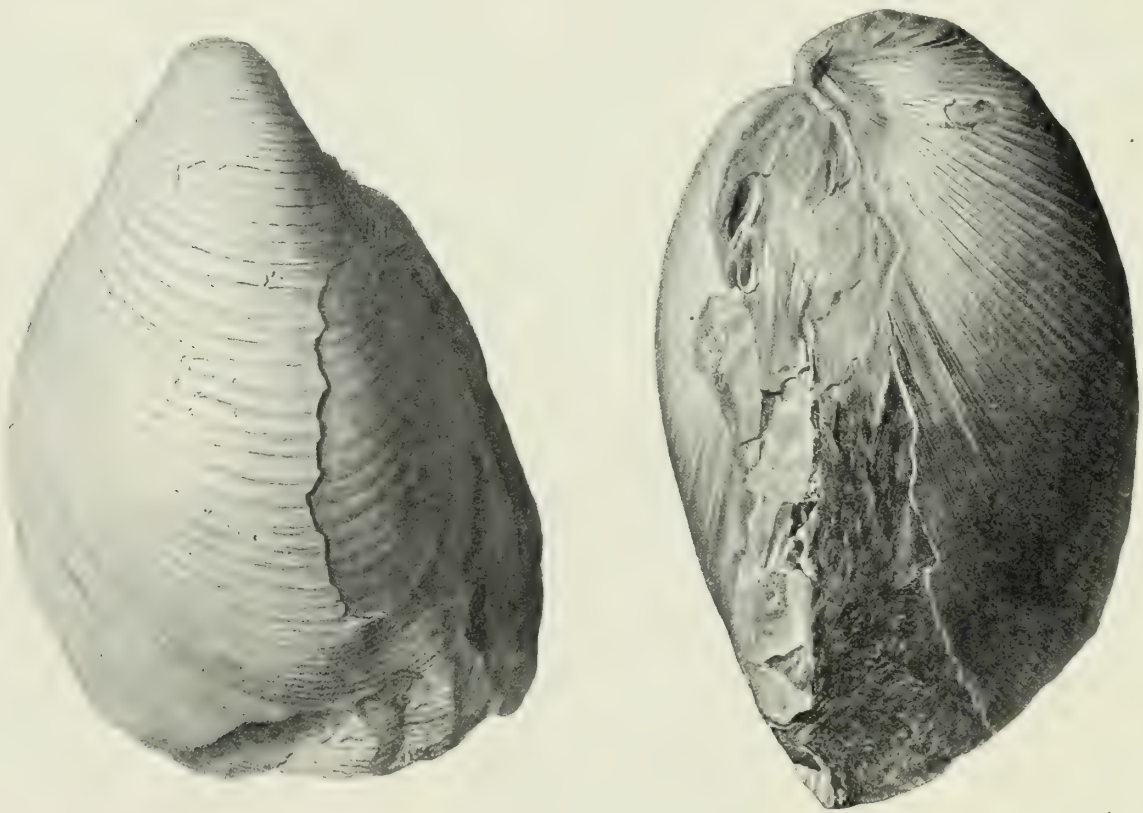

Fig. 31.—*Inoceramus tenuis*, Mantell. Chalk Marl, Hamsey. The type, No. 5890, British Museum (Nat. Hist.). The specimen is somewhat compressed from front to back. Left valve and anterior view of both valves. Right valve shown in the next figure.

prominent, the length of the shell is relatively greater, and the concentric rings are less prominent.

The fragmentary specimens described by Seeley as *Perna lissa* appear to belong to this species.[1]

Types.—In the British Museum (No. 5890) from the Chalk Marl of Hamsey. A fragment, from the Red Limestone of Hunstanton, which appears to be one of

[1] The form from the Red Limestone of Hunstanton which was named *Perna transversa* by Seeley is at present known only by an imperfect left valve. It is perhaps allied to *I. tenuis*, but is remarkable in being much longer than high. The type is in the Sedgwick Museum, Cambridge. Seeley, 'Ann. Mag. Nat. Hist.,' ser. 3, vol. xvii (1866), p. 179.

the specimens on which Seeley's description of *Perna lissa* was based, is in the Sedgwick Museum, Cambridge.

Fig. 32.—*Inoceramus tenuis*, Mantell. Right valve. See Fig. 31.

Distribution.—Red Limestone of Hunstanton, Louth, and Speeton. Upper Greensand of Ventnor and Potterne. Chalk Marl of Hamsey.

Inoceramus Crippsi, *Mantell*, 1822. Plate XLVIII, figs. 2, 3. Text-figs. 33—35.

1822.	Inoceramus Cripsii, *G. Mantell.*	Foss. S. Downs, p. 133, pl. xxvii, fig. 11.
1836.	— latus, *A. Goldfuss.*	Petref. Germ., vol. ii, p. 117, pl. cxii, fig. 5 (*non* Mantell).
1846.	— — *A. d'Orbigny.*	Pal. Franç. Terr. Crét., vol. iii, p. 513, pl. ccccviii, figs. 1, 2.
1854.	— Crispii, *J. Morris.*	Cat. Brit. Foss., ed. 2, p. 169.
1904.	— latus, *E. T. Newton and A. J. Jukes-Browne.*	In Jukes-Browne, Cret. Rocks of Britain, vol. iii, p. 449.
1909.	— Crippsi, *J. Böhm.*	Subhercyn. Kreidemulde (Abhandl. d. k. preuss. geol. Landesanst., n.f., 56), p. 41, pl. ix, fig. 1.

Non 1822. INOCERAMUS LATUS, *G. Mantell.* Foss. S. Downs, p. 216, pl. xxvii, fig. 10.
— 1828. — — *J. de C. Sowerby.* Min. Conch., vol. vi, p. 159, pl. dlxxxii, fig. 1.
— 1836. — CRISPII, *A. Goldfuss.* Petref. Germ., vol. ii, p. 116, pl. cxii, fig. 4.
— 1840. — — *H. B. Geinitz.* Char. d. Schicht. u. Petref. des sächs. Kreidegeb., pt. 1, p. 27.
— 1841. — LATUS, *F. A. Römer.* Die Verstein. d. nord-deutsch. Kreidegeb., p. 61.
— — — CRIPSII, *Römer.* Ibid., p. 63.
— 1846. — *H. B. Geinitz.* Grundr. d. Verstein., p. 464.
— — — LATUS, *Geinitz.* Ibid., p. 463.
— — *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 25.
— — CRIPSII, *Reuss.* Ibid., p. 25, pl. xxxvii, figs. 10, 12.
— 1847. — *J. Müller.* Petref. der Aachen. Kreidef., pt. 1, p. 30.
— 1852. — *F. Römer.* Kreidebild. v. Texas, p. 56, pl. vii, fig. 2.
— — LATUS, *Römer.* Ibid., p. 60.
— 1859. — CRISPII, *T. Wiltshire.* Red Chalk of England (Geol. Assoc.), p. 16, pl. i, fig. 4.
— 1863. — CRIPSI, *A. v. Strombeck.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xv, p. 152.
— 1866. — *K. A. Zittel.* Bivalv. d. Gosaugeb., ii (Denkschr. d. k. Akad. Wissensch., Wien, Math.-nat. Cl., vol. xxv), p. 95, pl. xiv, figs. 1—5, pl. xv, figs. 1—5.
— — LATUS, *Zittel.* Ibid., p. 100, pl. xiii, fig. 7.
— 1869. — CRIPSI, *E. Favre.* Moll. Foss. de la Craie de Lemberg, p. 132.
— 1870. — LATUS, *F. Römer.* Geol. Oberschles., p. 316, pl. xxxiv, fig. 12.
— — CRIPSII, *Römer.* Ibid., p. 356, pl. xxxix, fig. 9.
1871. — CRISPIANUS, *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, p. 405, pl. xxvii, figs. 1—3, pl. xxviii, fig. 2 (not pl. xxvii, fig. 3, *I. Heberti*, Fallot).
— 1872. — CRIPSI, *H. B. Geinitz.* Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 2), p. 49, pl. xiii, figs. 11–15.
— — LATUS, *Geinitz.* Ibid., p. 45, pl. xiii, figs. 4, 5.
1873. — — *Geinitz.* Neues Jahrb. für Min., etc., p. 11.
— — CRIPSI, *Geinitz.* Ibid., p. 16.
1875. — LATUS, *C. Décocq.* Assoc. Franç. Avanc. Sci. (Lille), p. 369.
— 1876. — CRIPSII, *D. Brauns.* Zeitschr. f. d. gesammt. Naturwissensch., vol. xlvi, p. 378.
— — — — ? var. BARABINI, *F. B. Meek.* Invert. Cret. Tert. Foss. U. Missouri, p. 49, pl. xii, fig. 3, pl. xiii, fig. 1.
— — — ? var. SUBUNDATUS, *F. B. Meek.* Bull. U.S. Geol. and Geogr. Surv. Territories, vol. ii, p. 358, pl. iii, figs. 1, 3.

Non 1877. Inoceramus Cripsii, *C. Schlüter.* Palæontographica, vol. xxiv, p. 277.
— 1878. — latus, *C. Barrois.* Ann. Soc. géol. Nord, vol. v, pp. 407, 475.
— 1879. — Cripsii, vars. proximus, suciensis, Barabini, *J. F. Whiteaves.* Mesozoic Foss., vol. i (Geol. Surv. Canada), pp. 172—174.
— 1882. — — *H. Schröder.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xxxiv, p. 273.
— 1885. — Cripsi, *E. Fallot.* Ann. Sci. géol., vol. xviii, p. 250.
— 1887. — Cripsii, *A. Peron.* Hist. Terr. Craie S.E. du Bassin Anglo-Parisien, p. 158.
— 1888. — — *G. Müller.* Jahrb. d. k. preuss. geol. Landesanst. für 1887, p. 416.
— 1889. — — *E. Holzapfel.* Die Mollusk. Aachen. Kreide (Palæontographica, vol. xxxv), p. 222.
— — — Cripsi, *A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat., iv, Teplitz. Schicht., p. 82, fig. 73.
— — — *O. Griepenkerl.* Senon. v. Königslutter (Palæont. Abhandl., vol. iv), p. 50.
— 1891. — Cripsii, *J. Böhm.* Palæontographica, vol. xxxviii, p. 81.
— 1892. — — *K. Futterer.* Ober. Kreidebild. St. Croce (Palæont. Abhandl., vol. vi), p. 80.
— — — Cripsi, *E. Stolley.* Kreide Schleswig-Holsteins (Mittheil. Min. Instit. Universit. Kiel, vol. i), p. 241.
— 1894. — Crippsi, *B. Lundgren.* Mammilatus och Mucronata zonerna (K. Svenska Vet.-Akad. Handl., n.f., vol. xxvi, No. 6), p. 45.
1897. — Cripsii, *R. Leonhard.* Palæontographica, vol. xliv, p. 49.
— — latus, *Leonhard.* Ibid., p. 49.
— 1898. — Cripsii, *G. Müller.* Mollusk. Untersen. v. Braunschweig u. Ilsede (Abhandl. d. k. preuss. geol. Landesanst., n.f., 25), p. 45, fig. 12.
— 1899. — — *G. de Alessandri.* Palæont. Ital., vol. iv, p. 194, pl. xvi, fig. 9.
— — — latus, *Alessandri.* Ibid., p. 196.
— 1900. — Cripsi, *A. Wollemann.* Jahrb. d. k. preuss. geol. Landesanst. für 1900, vol. xxi, p. 18.
— 1901. — latus, *F. Sturm.* Ibid., vol. xxi, p. 93, pl. x, fig. 2.
— — — Cripsi, *H. Imkeller.* Palæontographica, vol. xlviii, p. 33.
— 1902. — — var. radiosa, *A. Quaas.* Ibid., vol. xxx, 2, p. 170, pl. xx, figs. 9, 10.
— — — — *A. Wollemann.* Luneburg. Kreide (Abhandl. d. k. preuss. geol. Landesanst., n.f., 37), p. 72.
— 1903. — latus, *W. Petrascheck.* Jahrb. d. k. k. geol. Reichsanst., vol. liii, p. 165.

Non 1905.	Inoceramus Cripsi, *T. Wegner.*	Zeitschr. d. deutsch. geol. Gesellsch., vol. lvii, p. 161.
1906.	— Crispianus, *J. Pethö.*	Palæontographica, vol. lii, p. 232.
1908.	— Cripsii, *A. Stojanoff.*	Ann. géol. min. Russie, vol. x, p. 121.

Description.—Shell thin, equivalve, moderately inequilateral, convex between the umbo and the ventral margin; postero-dorsal part compressed and flattened; antero-dorsal marginal part nearly perpendicular to the plane of the valves and

Fig. 33.

Fig 34.

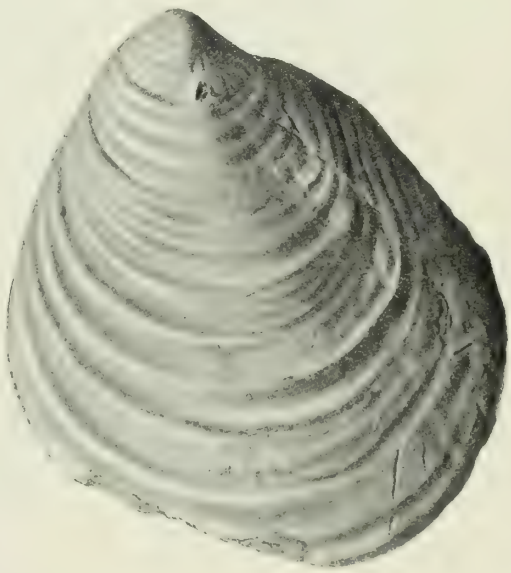

Fig. 33.—*Inoceramus Crippsi*, Mantell. The type, British Museum (Nat. Hist.) No. 5893. Chalk Marl, Offham. Internal cast. Natural size.
Fig. 34.—*Inoceramus Crippsi*, Mantell. Chalk Marl. Internal cast of a left valve similar to the type. British Museum (Nat. Hist.) No. 5895. Natural size.

nearly straight. Ventral margin convex; posterior margin only slightly convex, and forming more than a right angle with the hinge-line. Hinge-line forms an angle of about 140° with the antero-dorsal margin. Umbones inconspicuous, pointed, not curved, at about a third of the length of the hinge from the anterior end; in front of the umbones is a small, obtusely triangular ear.

Ornamentation consists of broad, rounded, rather irregular concentric ribs, which are strong anteriorly, and become weaker posteriorly. The curvature of the ribs is unsymmetrical; the anterior part curves rapidly, the postero-dorsal part is only slightly curved.

Affinities.—A species from the Senonian was figured and described by Goldfuss

as *I. Crippsi*, Mantell, and that identification has been accepted by many later writers. The type of *I. Crippsi* came from the Chalk Marl (zone of *Schlœnbachia varians*). From a study of a cast of the type, Petrascheck and J. Böhm[1] came to the conclusion that the Senonian species is quite distinct from *I. Crippsi*, and Böhm has named the former *I. balticus*. Böhm also supports the view first suggested by Messrs. E. T. Newton and A. J. Jukes-Browne, and confirmed by

Fig. 35.—*Inoceramus Crippsi*, Mantell. Upper Greensand, Haldon. Right valve. British Museum (Nat. Hist.), No. L17201. Natural size.

Petrascheck, that *I. latus* of Goldfuss and of d'Orbigny (but not of Mantell) is identical with *I. Crippsi*, Mantell. After a careful study of the type and other similar specimens of *I. Crippsi*, and of specimens of *I. latus*, I can fully support these conclusions.

I. cuneiformis, d'Orbigny,[2] is allied to *I. Crippsi*, but is relatively higher. One specimen found in the Upper Greensand of Warminster (Plate XLVIII, fig. 3),

[1] 'Subhercyn. Kreidemulde' (1909), pp. 41—46; Petrascheck, "Inoceram. a. d. Gosau," 'Jahrb. d. k. k. geol. Reichsanst.,' vol. lvi (1906), p. 155.

[2] 'Pal. Franc. Terr. Crét.,' vol. iii (1846), p. 512, pl. cccevii.

shows some resemblance to *I. cuneiformis*, but is probably only a rather high form of *I. Crippsi*, with which species it is found associated.

I. orbicularis, Goldfuss,[1] is regarded by Böhm as a small form of *I. Crippsi*, Mantell.

Type.—In the British Museum (fig. 33) from the Chalk Marl (zone of *Schlœnbachia varians*) of Offham.

Distribution.—Upper Greensand of Haldon. Upper Greensand (zone of *Pecten asper*) of Warminster and Devizes. Chalk Marl (zone of *Schlœnbachia varians*) of Ringmer, Hamsey, Offham, Maiden Newton, Eggardon Hill, Pyrton, Chalton, Arlesey, Hunstanton, and Donnington (Lincolnshire). Cenomanian of Wilmington (Devon). Lower Chalk (zone of *Holaster subglobosus*) of Totternhoe, Burham, and Cherry Hinton.

INOCERAMUS CRIPPSI *var.* REACHENSIS, *Etheridge*, 1881. Plate XLVIII, figs. 4, 5; Plate XLIX, fig. 1.

1881. INOCERAMUS LATUS var. REACHENSIS, *R. Etheridge*. In Penning and Jukes-Browne, Geol. Cambridge, p. 142, pl. i, fig. 3.

Remarks.—In this form, which is mainly characteristic of the zone of *Holaster subglobosus*, the ribs are more sharply defined, their ventral curvature is greater, and their posterior part is less nearly straight than in *I. Crippsi*.

Type.—From the Totternhoe Stone of Burwell, in the Sedgwick Museum, Cambridge.

Distribution.—Chalk Marl of Blue Bell Hill, Burham. Zone of *Holaster subglobosus* of Merstham and Blue Bell Hill, Burham. Totternhoe Stone (zone of *H. subglobosus*) of Burwell. Recorded by Etheridge from the Chalk Marl of Reach.

INOCERAMUS ETHERIDGEI, *nom. nov.* Plate XLIX, figs. 2—4.

1881. INOCERAMUS CONVEXUS, *R. Etheridge*. In Penning and Jukes-Browne, Geol. Cambridge, p. 143, pl. ii, fig. 6.

— — — var. QUADRATUS, *Etheridge*. Ibid., p. 143, pl. ii, fig. 7.

— — STRIATUS var. CONVEXUS, *A. J. Jukes-Browne*. Cret. Rocks of Britain, vol. iii, p. 476.

[1] 'Petref. Germ.,' vol. ii (1836), p. 117, pl. cxiii, fig. 2. Böhm, 'Subhercyn. Kreidemulde' (1909), p. 46, pl. xi, fig. 1.

Non 1855. Inoceramus convexus, *J. Hall* and *F. B. Meek*. Foss. Cret. Nebraska (Mem. Amer. Acad. Arts and Sci., vol. v), p. 386, pl. ii, fig 2.

Description.—Valves nearly equal, considerably inequilateral, tumid, compressed near the postero-dorsal margin; height greater than length. Antero-dorsal margin nearly straight; ventral margin usually very convex; posterior margin slightly or moderately convex, forming an obtuse angle with the hinge-line. Anterior marginal parts more or less nearly perpendicular to the plane of the valves, sometimes concave near the umbo. Umbones terminal, curved inwards and forwards. Angle between the hinge-line and the anterior margin is about 115°. The height of the shell is nearly twice the length of the hinge.

Ornamentation consists of faintly marked concentric undulations and numerous growth-lines.

Affinities.—In this species the antero-dorsal margin is relatively longer and more nearly straight, and the postero-dorsal part of the shell less compressed than in *I. tenuis*, Mantell.

I. convexus var. *quadratus*, Etheridge, was founded on a specimen in which the anterior part of the shell is pressed in, giving rise to the appearance of a carina at the upper margin of the antero-dorsal slope.

Types.—From the Totternhoe Stone of Burwell, in the Sedgwick Museum, Cambridge.

Distribution.—Upper Greensand (zone of *Pecten asper*) of Warminster. Cenomanian of Wilmington, Devon. Chalk Marl of Branscombe, Beer Head, Titherleigh (near Chard) and Hunstanton. Totternhoe Stone (zone of *Holaster subglobosus*) of Burwell.

Inoceramus pictus, *Sowerby*, 1829. Plate XLIX, figs. 5, 6. Text-fig. 36.

1829. Inoceramus pictus, *J. de C. Sowerby*. Min. Conch., vol. vi, p. 215, pl. dciv, fig. 1.

1854. — pictus, *J. Morris*. Cat. Brit. Foss., ed. 2, p. 170.

1867. — angulatus, *E. Guéranger*. Album Paléont. de la Sarthe, p. 20, pl. xxv, fig. 7 (? I. angulatus, *d'Orbigny*, 1846).

1904. — pictus, *E. T. Newton* and *A. J. Jukes-Browne*. In Jukes-Browne, Cret. Rocks of Britain, vol. iii, p. 450.

Description.—Shell equivalve, very inequilateral, slightly or moderately convex with flattened sides; the postero-dorsal part compressed. Antero-dorsal marginal

part flattened or concave, and more or less nearly perpendicular to the plane of the valves. Ventral margin very convex; posterior margin moderately convex. Umbones terminal, incurved. Hinge-line nearly at right angles to the anterior margin. Ornamentation consists of numerous strong, somewhat irregular concentric ribs, separated by concave interspaces. The curvature of the ribs is unsymmetrical, and the ribs become less distinct on the antero-dorsal and postero-dorsal parts of the valves.

Affinities.—This species shows some resemblance to *I. anglicus*, but possesses more numerous ribs, and also differs in the anterior part of the shell being flat or

Fig. 36.—*Inoceramus pictus*, Sow. Chalk Marl, Guildford. British Museum No. 43272. The Type. Natural size.

concave. The type and some other specimens (*e. g.* No. 73339, British Museum) show traces of the original colouring of the shell. An example of this species was figured by Guéranger as *I. angulatus*, d'Orbigny,[1] but appears to be quite distinct from that form.

Type.—From the Chalk Marl of Guildford, in the British Museum (Natural History).

Distribution.—Lower Chalk (zone of *Holaster subglobosus*) of Beachy Head, Burham, Rochester, and the Gog-ma-gogs, near Cambridge. Chalk Marl of Burham and Guildford.

[1] 'Pal. Franç. Terr. Crét.,' vol. iii (1846), p. 515, pl. cccviii, figs. 3, 4. In the text the spelling is *angulosus*.

INOCERAMUS LABIATUS (*Schlotheim*), 1813. Plate L. Text-fig. 37.

1768. OSTRACITES, *J. E. I. Walch.* Die Naturgesch. Verstein z. Erläut. d. Knorrischen Samml. v. Merkwürdigk. d. Natur., II, p. 84, pl. B II *b**, fig. 2; p. 152, pl. dx, figs. 1, 2.

1813. — LABIATUS, *E. F. v. Schlotheim.* In Leonhard's Taschenbuch für Min., vol. vii, p. 93.

— PINNITES DILUVIANUS, *Schlotheim.* Ibid., p. 93.

1820. — — *Schlotheim.* Petrefactenk., p. 303.

1822. MYTILOIDES LABIATUS, *A. Brongniart.* In Cuvier, Ossemens Fossils, vol. ii, pt. 2, pp. 320, 597, pl. iii, fig. 4.

1822. INOCERAMUS MYTILLOIDES, *G. Mantell.* Foss. S. Downs, p. 215, pl. xxvii, fig. 3; pl. xxviii, fig. 2.

1823. — MYTILOIDES, *J. de C. Sowerby.* Min. Conch., vol. v, p. 62, pl. ccccxlii (not the two smaller figures).

1827. CATILLUM SCHLOTHEIMI, *S. Nilsson.* Petrif. Suecana, p. 19.

1836. INOCERAMUS MYTILOIDES, *A. Goldfuss.* Petref. Germ., vol. ii, p. 118, pl. cxiii, fig. 4.

? 1837. CATILLUS MYTILOIDES, *G. G. Pusch.* Polens Paläont., p. 45.

1841. INOCERAMUS MYTILOIDES, *F. A. Römer.* Die Verstein. d. nord-deutsch. Kreidegeb., p. 63.

1846. — PROBLEMATICUS, *A. d'Orbigny.* Pal. Franç. Terr. Crét., vol. iii, p. 510, pl. cccvi, figs. 1—7 (Non. *I. problematicus*, v. Schlotheim).

— — MYTILOIDES, *A. E. Reuss.* Die Verstein. der böhm. Kreideformat., pt. 2, p. 26, pl. xxxvii, fig. 16.

— — — *H. B. Geinitz.* Grundr. d. Verstein., p. 463.

? 1847. — — *A. d'Archiac.* Mém. Soc. géol. de France, ser. 2, vol. ii, p. 307.

1850. — PROBLEMATICUS, *A. d'Orbigny.* Prodr. de Pal., vol. ii, p. 197.

— — MYTILOIDES, *H. B. Geinitz.* Das Quadersandst. oder Kreidegeb. in Deutschland, p. 176.

? 1852. — — *F. Römer.* Kreidebild. v. Texas, p. 60, pl. vii, fig. 5.

1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 170 (*partim*).

1863. — — *A. v. Strombeck.* Zeitschr. d. deutsch. geol. Gesellsch., vol. xv, p. 119.

? 1870. — LATUS, *F. Römer.* Geol. v. Oberschles., p. 316, pl. xxxiv, fig. 12.

1871. — LABIATUS, *F. Stoliczka.* Palæont. Indica, Cret. Fauna S. India, vol. iii, p. 408, pl. xxix, fig. 1.

1872.	Inoceramus labiatus, *H. B. Geinitz.*		Das Elbthalgeb. in Sachsen (Palæontographica, vol. xx, pt. 2), p. 46, pl. xii, figs. 1—3.
1873.	—	—	*Geinitz.* Neues Jahrb. für Min , etc., p. 13.
1877.	—	—	*C. Schlüter.* Palæontographica, vol. xxiv, p. 262.
—	—	—	*A. Fritsch.* Stud. im Gebiete der böhm. Kreideformat. ii, Weissenberg. u. Malnitz. Schicht., p. 130, fig. 112.
? 1888.	—	—	*S. Nikitin.* Les Vestiges Crét. Russ. centrale (Mém. Comité géol. Russ., vol. v, no. 2), p. 34, pl. 5, figs. 10, 11.
1888.	—	—	*A. Peron.* Hist. Terr. de Craie dans le S.E. du Bassin Anglo-Parisien, p. 158.
1893.	—	—	*R. Michael.* Zeitschr. der deutsch. geol. Gesellsch., vol. xlv, p. 241.
—	—	—	*T. W. Stanton.* The Colorado Formation (Bull. U.S. Geol. Surv., No. 106), p. 77, pl. x, fig. 4; pl. xiv, fig. 2.
? 1897.	—	—	*R. Leonhard.* Kreideformat. in Oberschles. (Palæontographica, vol. xliv), p. 48.
1903.	—	—	*W. Petrascheck.* Jahrb. d. k. k. geol. Reichsanst., vol. liii, p. 156.
? Non 1868.	—	mytiloides, *E. Eichwald.*	Lethæa Rossica, vol ii, p. 492, pl. xxi, fig. 6.
— 1881.	—	(Mytilites) problematicus, *R. Etheridge.*	In Penning and Jukes-Browne, Geol. Cambridge, p. 143, pl. iii, figs. 9—11.

Description.—Shell mytiliform, nearly equivalve, extremely inequilateral, oblique, much elongated between the umbo and the postero-ventral extremity, convex, with a small posterior ear; antero-dorsal part sloping steeply and sometimes concave. Angle formed by the hinge with the antero-dorsal margin about 90°. Umbones terminal, with a slight anterior curvature. Anterior margin gently curved; postero-ventral extremity very convex; posterior margin nearly straight.

Ornamentation consists of small, fairly regular concentric undulations, which have an unsymmetrical curvature in the young, but become more nearly symmetrical in older specimens. On the old parts of the shell the undulations become less distinct.

Affinities.—It seems probable that this species is related to *I. Crippsi* var. *reachensis* (p. 278), but the height of the shell is relatively greater, the length of the hinge-line is less, and the direction of growth is oblique to the hinge-line.

I. propinquus, Goldfuss,[1] from the Quader-sandstone of Schandau, was regarded by Geinitz as a synonym of *I. labiatus*.

[1] 'Petref. Germ.,' vol. ii (1836) p. 112, pl. cix, fig. 9.

D'Orbigny identified this species with *I. problematicus*, von Schlotheim, which comes from the Senonian, and has been shown by Böhm to be distinct from the Turonian form.[1]

Remarks.—This species is mainly characteristic of the zone of *Rhynchonella Cuvieri*. In the zone of *Terebratulina lata* it is not common, and the shell is usually relatively longer than in typical forms of the species.

Types.—The type came from the Turonian of Pirna. The specimens figured by Mantell from the zone of *Rhynchonella Cuvieri* of Plumpton are in the British Museum. The large specimen figured by Sowerby from Warminster cannot be found.

Distribution.—Zone of *Rhynchonella Cuvieri* of the Devon and Dorset coasts, the Isle of Wight, Winchester, Eastbourne, Lewes, Plumpton, Dover, Blue Bell Hill (Burham), Betchworth, Watlington (Berkshire), Hitchin, Cherry Hinton, South Thoresby, South Ferriby (Lincolnshire), and the Yorkshire coast. Zone of *Terebratulina lata* of the Devon and Dorset coasts, Winchester, Eastbourne, and Dover.

Recorded by Jukes-Browne from the zone of *Holaster subglobosus* of Cambridge-

Fig. 37.

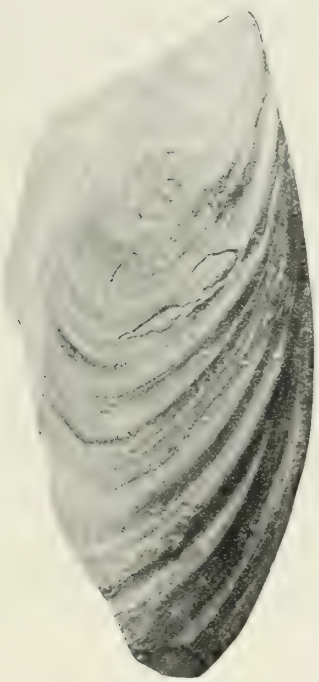

Fig. 38.

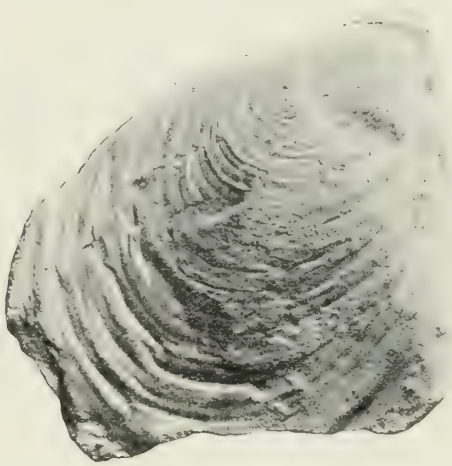

Fig. 37.—*Inoceramus labiatus* (Schloth). The type of *Inoceramus mytiloides*, Mantell, 'Foss. S. Downs,' p. 215, pl. xxviii, fig. 2. Zone of *Rhynchonella Cuvieri*, Plumpton. British Museum. Natural size.
Fig. 38.—*Inoceramus labiatus* var. *latus*, Sow. Zone of *Holaster planus*, Purley Junction Station. British Museum, No. L21194. Natural size.

[1] J. Böhm, 'Monatsber. d. deutsch. geol. Gesellsch.' (1909), p. 117.

shire and West Norfolk; and by Rowe from the zone of *Holaster planus* of Dover and the Sussex coast, and from the zone of *Micraster cor-testudinarium* of Dover.

Fig. 39. Fig. 40.

Fig. 39.—*Inoceramus labiatus* var *latus*, Sow. Zone of *Holaster planus*, Swaffham, Norfolk. Norwich Museum, No. 3296. Right valve and anterior view. Natural size.
Fig. 40.—*Inoceramus labiatus* var. *latus*, Sow. One of the types of *Inoceramus latus*, Sowerby, 'Min. Conch.,' vol. vi, p. 159, pl. dlxxxii, fig. 1 (lower figure). Swaffham. British Museum, No. 43266. Natural size.

Inoceramus labiatus *var.* latus, *Sowerby*, 1828. Text-figs. 38—40.

1828. Inoceramus latus, *J. de C. Sowerby.* Min. Conch., vol. vi, p. 159, pl. dlxxxii, fig. 1. (Non *I. latus*, Mantell).
1854. — — *J. Morris.* Cat. Brit. Foss., ed. 2, p. 170 (*partim*).

Remarks.—This variety differs from *I. labiatus* in the much greater length of the hinge-line in proportion to the height of the shell, in the greater convexity of the anterior margin, the smaller convexity of the ventral margin, and the less oblique form of the shell. On account of the greater length of the hinge-line the curvature of the ribs and growth-lines is broader than in *I. labiatus*.

This variety appears to be confined to the zone of *Holaster planus*, and is common in the neighbourhood of Swaffham, Norfolk. The larger specimens which I have seen are not sufficiently perfect for figuring, but a characteristic example is figured by Sowerby.

Types.—From the zone of *Holaster planus* of Swaffham. The smaller specimen figured by Sowerby is in the British Museum (Fig. 40), but the larger specimen cannot be found.

Distribution.—Zone of *Holaster planus* of Purley Junction Station, Surrey, and Swaffham, Norfolk.

PLATE XLV.

Genus—INOCERAMUS, *Sowerby*.

FIGS.

1, 2. *I. neocomiensis*, d'Orb. 1, Hythe Beds, Lympne. Museum of Practical Geology, No. 21133. Left valve. 2, Lower Greensand, Atherfield. Sedgwick Museum, Cambridge. Right valve. (P. 262.)

3—7. *I. Salomoni*, d'Orb. *Mammillatus* bed, Copt Point, Folkestone. Sedgwick Museum. Internal casts of left valves. 4 *b*, dorsal view of 4 *a*. (P. 263.)

8—10. *I. anglicus*, Woods. (P. 264.)

8. Red Limestone, Hunstanton. Sedgwick Museum. *a*, part of right valve; *b*, dorsal view.

9. Gault, Folkestone. Sedgwick Museum. Left valve.

10. Gault, Folkestone. British Museum, No. L9665. Right valve.

11. *I. concentricus*, Park. Gault, Folkestone. British Museum, No. L5002. Left valve. (P. 265.)

CRETACEOUS LAMELLIBRANCHIA.

T. A. Brock del.

London Stereoscopic Co. Imp.

PLATE XLVI.

Inoceramus (*continued*).

Figs.

1—10. *I. concentricus*, Park. 1—7, Gault, Folkestone. 8—10, Upper Greensand, Blackdown. (P. 265.)

1. British Museum, No. L5002. Right valve and umbo of left valve.
2. Sedgwick Museum, Cambridge. Right valve and umbo of left valve.
3. Sedgwick Museum. *a*, left valve; *b*, dorsal view of the same.
4. Sedgwick Museum. *a*, left valve; *b*, anterior view of both valves.
5. Sedgwick Museum. *a*, left valve, *b*, dorsal view of both valves.
6. Sedgwick Museum. Right valve.
7. Sedgwick Museum. Left valve.
8. Museum of Practical Geology, No. 21183. *a*, right valve; *b*, dorsal view of the same.
9. Sedgwick Museum. *a*, right valve and umbo of left valve; *b*, dorsal view of both valves.
10. Bristol Museum. *a*, right valve and part of displaced left valve; *b*, anterior view of both valves.

CRETACEOUS LAMELLIBRANCHIA.

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PLATE XLVII.

Inoceramus (*continued.*)

Figs.

1, 2. *I. concentricus*, Park. 1, Upper Greensand, Blackdown. Bristol Museum. Left valve. 2, Red Limestone, Hunstanton. Sedgwick Museum, Cambridge. Left valve. (P. 265.)

3—14. *I. concentricus* var. *subsulcatus*, Wiltsh. Gault, Folkestone. Left valves. (P. 268.)

3, 4. Sedgwick Museum, Cambridge.
5. Museum of Practical Geology, No. 21154.
6. British Museum, No. L5003.
7—9. Sedgwick Museum.
10. British Museum, No. L9664.
11—13. Sedgwick Museum.
14. Museum of Practical Geology, No. 21153.

15—20. *I. sulcatus*, Park. Gault, Folkestone. 15, British Museum, No. L11797; *a*, left valve; *b*, right valve; *c*, dorsal view. 16—20, Sedgwick Museum. 16, 18—20, left valves; 17, anterior view. (P. 269.)

CRETACEOUS LAMELLIBRANCHIA.

T. A. Brock del.

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PLATE XLVIII.

Inoceramus (*continued*).

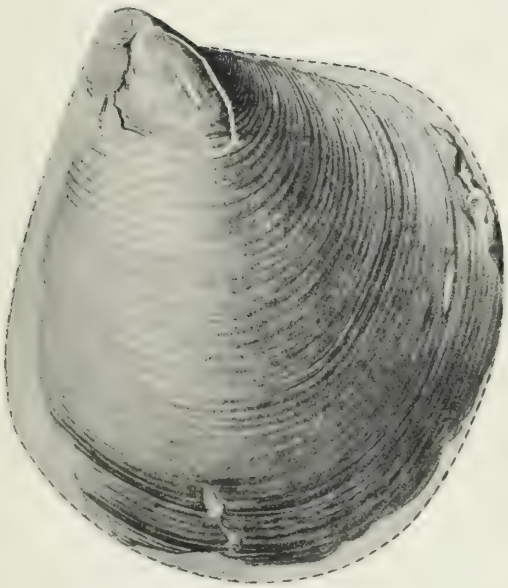
Figs.

1. *I. tenuis*, Mant. Red Limestone, near Louth. Sedgwick Museum, Cambridge. *a*, left valve; *b*, dorsal view. (P. 271.)

2, 3. *I. Crippsi*, Mant. Upper Greensand (zone of *Pecten asper*), Warminster. (P. 273.)

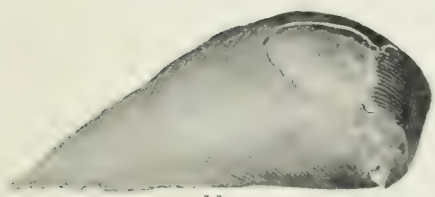
2. Museum of Practical Geology, No. 18898. *a*, right valve; *b*, dorsal view.
3. High variety. Sedgwick Museum. Right valve.

4, 5. *I. Crippsi* var. *reachensis*, Eth. Lower Chalk (zone of *Holaster subglobosus*), Blue Bell Hill, Burham. 4, British Museum, No. L10386. Left valve. 5, Mr. Dibley's Collection. Right valve. (P. 278.)

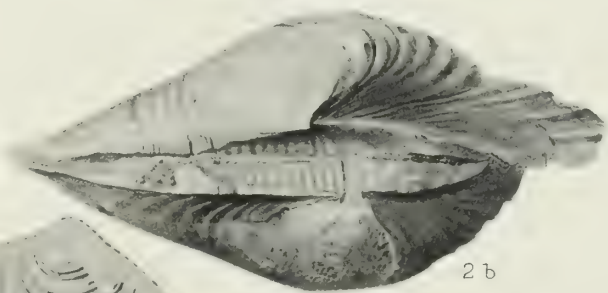


1a

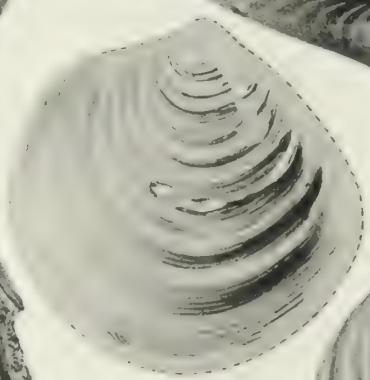
2a



1b

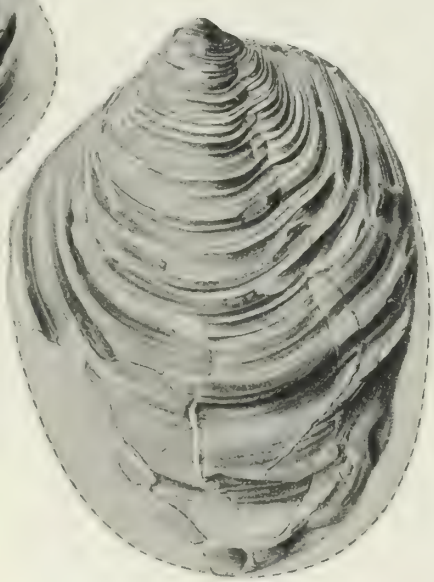


2b



5

3



4

CRETACEOUS LAMELLIBRANCHIA.

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PLATE XLIX.

Inoceramus (*continued*).

Figs.

1. *I. Crippsi* var. *reachensis*, Eth. Lower Chalk (zone of *Holaster subglobosus*), Blue Bell Hill, Burham. British Museum, No. L10387. Right valve. (P. 278.)

2—4. *I. Etheridgei*, Woods. Lower Chalk. Sedgwick Museum, Cambridge. (P. 278.)

2. Chalk Marl, Hunstanton. *a*, left valve; *b*, hinge of the same.

3, 4. Totternhoe Stone (zone of *Holaster subglobosus*), Burwell. 3, one of the types; *a*, left valve; *b*, dorsal view of the same. 4, Right valve.

5, 6. *I. pictus*, Sow. Lower Chalk. (P. 279.)

5. Zone of *Holaster subglobosus*, Burham. British Museum, No. 44683. Right valve.

6. Locality unknown. British Museum, No. L22259. Left valve.

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PLATE L.

Inoceramus (*continued*).

Figs.

1—6. *I. labiatus* (Schloth.). Middle Chalk. (P. 281.)

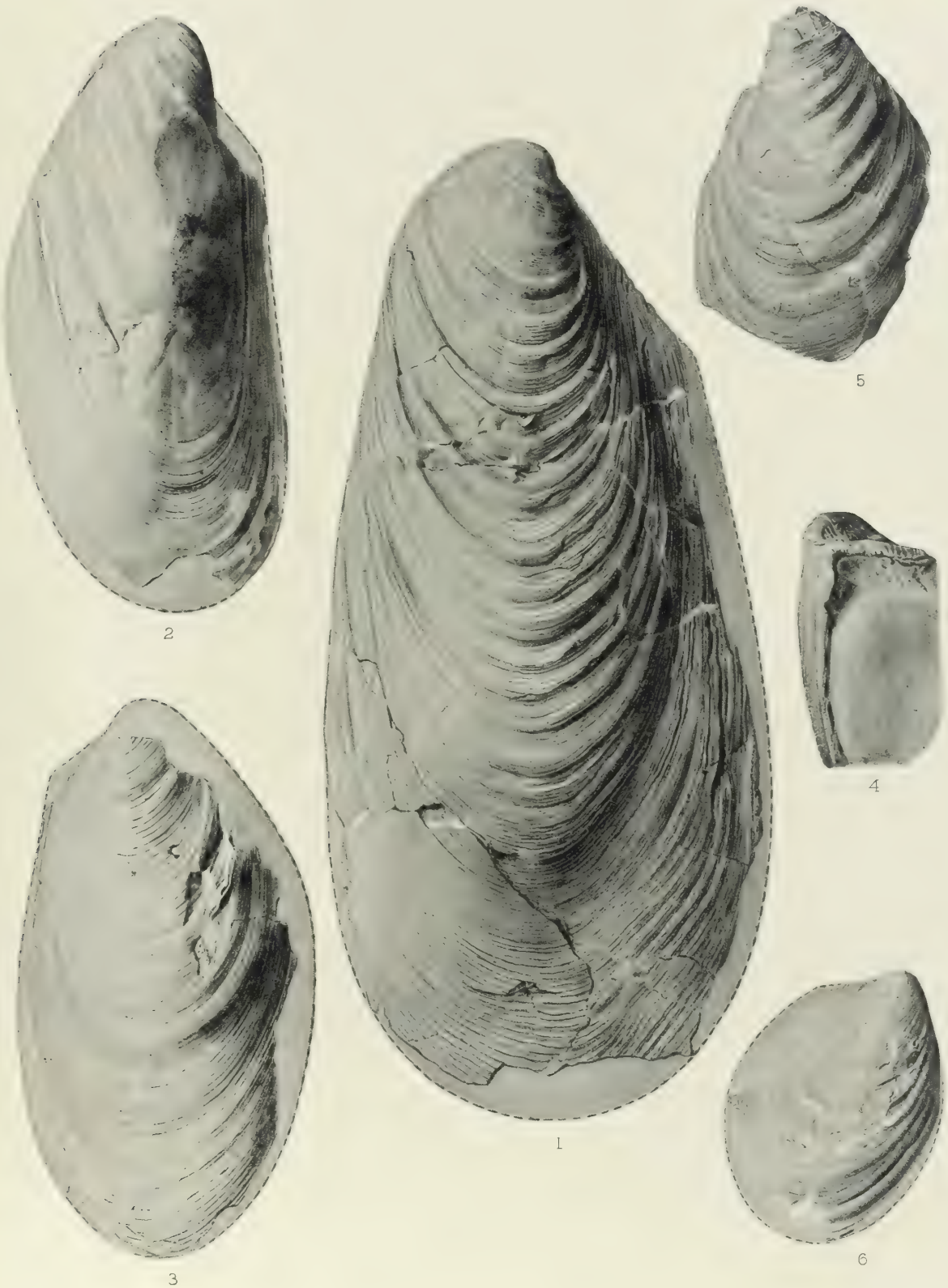
1. Locality unknown. British Museum, No. L20943. Left valve.

2, 3. Eastbourne. Sedgwick Museum. 2, Left valve. 3, Right valve.

4. Zone of *Rhynchonella Cuvieri*, Blanc Nez, Pas de Calais. Sedgwick Museum. Hinge and anterior margin of right valve.

5. Plumpton. British Museum, No. 5861. The specimen figured by Mantell, Foss. S. Downs, pl. xxvii, fig. 3, p. 216. Right valve.

6. Middle Chalk, near Warminster. Dr. Blackmore's Collection. Right valve.



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A MONOGRAPH

OF THE

TERRESTRIAL CARBONIFEROUS ARACHNIDA

OF

GREAT BRITAIN.

BY

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A MONOGRAPH

OF THE

TERRESTRIAL CARBONIFEROUS ARACHNIDA OF GREAT BRITAIN.

I.—INTRODUCTION.

Most of the material upon which this monograph is based came from Coseley, near Dudley, and was kindly lent to me by the following gentlemen, to whom my grateful thanks are due: Dr. Wheelton Hind, Mr. S. Priest, Mr. Henry Johnson, the late Mr. William Madeley, and Mr. Walter Egginton. I am also greatly indebted to the Director of the Geological Survey and to Dr. Kitchin for the loan of specimens from the Survey Museum in Jermyn Street; to Dr. Smith Woodward, the Keeper, and to Dr. F. A. Bather, the Assistant-Keeper, of the Geological Department of the British Museum, not only for the loan of specimens, but also for the privilege of free access to the collection of fossil Arachnida in that institution; to Dr. Henry Woodward for the opportunity to examine and describe examples that had been entrusted to him by Dr. Moysey, Mr. W. A. Parker, and Mr. F. Holt; and to Mr. Robert Dunlop for two very interesting specimens from Scotland. Without the help thus generously afforded, the present work could not have been attempted. Finally, I wish to thank Miss Gertrude M. Woodward for the care she has taken in the execution of the plates and text-figures illustrating this monograph.

The species forming the subject-matter of the following pages are referred to seven orders: Scorpiones, Pedipalpi, Araneæ, Ricinulei, Haptopoda, Phalangiotarbi, and Anthracomarti, one species doubtfully belonging to the Opiliones. The Haptopoda, Phalangiotarbi, and Anthracomarti are, so far as is known, wholly extinct. I am unable to offer any satisfactory suggestion as to the cause of their extinction, there being nothing in their organisation very obviously calculated to make them less fitted for survival than the Ricinulei. The reason for the survival of Scorpiones and Pedipalpi is perhaps to be found partly in their possession of

powerful chelate palpi. But in addition to these efficient prehensile organs the Scorpiones have a poisonous sting; the Uropygous Pedipalpi have protective acid-glands at the tip of the opisthosoma, while the Amblypygi are extraordinarily quick in their movements and have a highly specialised tactile organ in the legs of the first pair. The Araneæ have probably survived in virtue of their snare- and cocoon-making spinning glands, coupled with poison-glands in the mandibles; and there is some evidence that existing Opiliones are protected by their scent-glands. Since there is no reason to suppose that the members of the extinct orders above enumerated had specialised glands either for offensive or defensive purposes, and since their palpi were short and non-prehensile, and their organisation suggests that they were comparatively slow-moving, cryptozoic forms, it might be supposed that these attributes supply the needed explanation, were it not that the Ricinulei resemble them in most of these particulars. One thing, however, must not be forgotten. An important factor in the evolution of terrestrial Arachnida has been, in my opinion, a change from the method of pairing, as practised by Scorpions, to new and special methods, resulting in the modification of a part of one of the prothoracic limbs into an intromittent organ, often of great complexity. This may be seen in the Araneæ, where the palpi are modified, in the Solifugæ, where the mandibles are modified, in some of the Acari, and lastly in the Ricinulei, where the legs of the third pair are modified. Even the Opiliones possess very special secondary reproductive organs. There is no evidence, nor any reason to suppose, that the Haptopoda, Phalangiotarbi, or Anthracomarti had departed from the normal in their breeding habits; and it is quite conceivable that the Ricinulei have outlasted their Carboniferous contemporaries belonging to those three orders on account of their very specialised methods of copulation.

Up to the present time the only orders of Arachnida known to be represented in British Carboniferous strata, belong to the Scorpiones, the Phalangiotarbi, and the Anthracomarti. Of Scorpiones several species have been described, mostly by Dr. Peach from Scotland; one species of Phalangiotarbi was named many years ago by Dr. Woodward; while of Anthracomarti some five species have been made known by Dr. Woodward and myself. As an historical fact it is interesting to record that in 1826 Dean Buckland described two Arachnida as Coleopterous insects. One of these was detected to be an Arachnid by Dr. Woodward, and the other I have now been able to identify as also belonging to that class.

The material at my disposal has shown that the British Carboniferous fauna is at least as rich in species and genera of Arachnida as that of Continental Europe and North America, the species of which have been described for the most part respectively by Kusta and Fritsch and by Scudder. Fritsch can hardly be acquitted of the charge of needlessly creating species and genera. Scudder's work on the contrary is open to no such accusation. It appears to me that in the present state of our knowledge of this group, species in themselves are of very little importance.

Whenever possible, therefore, I have avoided making them. The characters of the orders, families, and often of the genera are, on the contrary, of the highest interest. They show that the Pedipalpi, Araneæ and Ricinulei, and some of the Scorpiones have existed almost unchanged down to the present day; and that other Scorpions, on the other hand, *e. g. Eobuthus*, differed considerably from modern types in one feature at least, which may be described as Merostomatous. Apart from this one fact, and for a possibly closer connection between the spider named *Arthrolycosa* and the Amblypygous Pedipalpi than exists in modern types, these orders were as sharply defined as they are now; and unless, as is possible, the extinct orders, Haptopoda, Anthracomarti and Phalangiotarbi, serve to bridge to a certain extent the interval between the Opiliones and more primitive orders of Arachnida, it can hardly be claimed that the Carboniferous fauna throws much, if any, light upon the origin and mutual relationship of existing orders of the class. In other words, the available palæontological data supplied by a study of these Carboniferous Arachnida do not furnish any strong evidence in favour of the evolution of the class. Hence, for the common stock whence the Epectinate Arachnida originated, we must look to deposits much earlier than those laid down in the Carboniferous epoch.

II.—ANNOTATED REVISION OF PREVIOUSLY PROPOSED CLASSIFICATIONS OF CARBONIFEROUS ARACHNIDA.

1. Karsch, F. E., Zeitschr. deutsch. geol. Ges., 1882, pp. 556—561.

Order 1. ARANEÆ.
Family Liphistiidæ.
Genus **Protolycosa**, Roemer: *P. anthracophila*, Roemer.
Order 2. OPILIONES.
Family Trogulidæ.
Genus **Kreischeria**, Geinitz: *K. wiedei*, Geinitz.
Order 3. ANTHRACOMARTI.
Family Architarbidæ.
Genus **Architarbus**, Scudder: *A. rotundatus*, Scudder; *subovalis*, Woodward; *silesiacus*, Roemer.
Genus **Anthracomartus**, nov.: *A. völkelianus*, nov.
Family Eophrynidæ.
Genus **Eophrynus**, Woodward: *E. prestvicii*, Buckland.
Order 4. SCORPIONES.
Genus **Eoscorpius**, Meek and Worthen: *E. anglicus*, Woodward; *carbonarius*, Meek and Worthen.
Genus **Microlabis**, Corda: *M. sternbergi*, Corda.
Genus **Cyclophthalmus**, Corda: *C. senior*, Corda.
Genus **Mazonia**, Meek and Worthen: *M. woodiana*, Meek and Worthen.

Observations.—*Protolycosa* is very likely correctly referred to the Liphistiidæ. *Kreischeria* does not belong to the Trogulidæ of the order Opiliones, but is closely related to *Eophrynus*. The order Anthracomarti contains the elements of two orders; and the Architarbidæ the elements of two distinct families. The Architarbidæ, with *Architarbus*, should be eliminated from the Anthracomarti, and *Anthracomartus* left in the order as the type of a family—distinct from the Eophrynidæ.

2. Scudder, S. H., Proc. Amer. Acad. Arts and Sci., vol. xx, 1884, pp. 15—22.

Order ANTHRACOMARTI.
Family 1. Arthrolycosidæ.
Genus **Arthrolycosa**, Harger: *A. antiqua*, Harger.
Family 2. Poliocheridæ, nov.
Genus **Poliochera**, nov.: *P. punctulata*, sp. n.
Family 3. Architarbidæ.
Genus **Geraphrynus**, nov.: *G. carbonarius*, sp. n.
Genus **Architarbus**, Scudder: *A. rotundatus*, Scudder; *subovalis*, Woodward (= ? *Curculioides ansticii*, Buckland); *silesiacus*, Roemer.
Genus **Anthracomartus**, Karsch: *A. völkelianus*, Kusta; *krejcii*, Kusta; *trilobitus*, nov.; *pustulatus*, nov.
Family 4. Eophrynidæ.
Genus **Eophrynus**, Woodward: *E. prestvicii*, Buckland; *E. salmi*, Stur.
Order PEDIPALPI.
Genus **Geralinura**, nov.: *G. carbonaria*, sp. n.
Order SCORPIONES.
Family Eoscorpionidæ.
Genus **Eoscorpius**, Meek and Worthen: *E. carbonarius*, Meek and Worthen; *anglicus*, Woodward; *euglyptus*, *glaber*, *inflatus*, *tuberculatus*, Peach.
Genus **Cyclophthalmus**, Corda: *C. senior*, Corda (= *Microlabis sternbergi*).
Genus **Mazonia**, Meek and Worthen: *M. woodiana*, Meek and Worthen.
Order ARANEÆ.
Family Liphistiidæ.
Genus **Protolycosa**, Roemer: *P. anthracophila*, Roemer.
Genus **Palaranea**, Fritsch: *P. borassifolia*, Fritsch.

3. Scudder, S. H., Mem. Boston Soc. Nat. Hist., vol. iv, 1890, pp. 443—456.

Scudder's final classification of the American forms, omitting Araneæ and Scorpiones, was as follows:

Order ANTHRACOMARTI.
Family 1. Poliocheridæ.
Genus **Poliochera**, Scudder: *P. punctulata*, Scudder.

Family 2. ARCHITARBIDÆ.
Genus **Geraphrynus**, Scudder: *G. carbonarius*, Scudder.
Genus **Geratarbus**, nov.: *G. lacoei*; *scabrum*, spp. n.
Genus **Architarbus**, Scudder: *A. rotundatum*, Scudder; *elongatum*, sp. n.
Genus **Kustarachne**, nov.: *K. tenuipes*, sp n.
Genus **Anthracomartus**, Karsch: *A. trilobitus*, Scudder; *pustulatus*, Scudder.
Order PEDIPALPI.
Family GERALINURIDÆ.
Genus **Græophonus**, nov.: *G. carbonarius*, sp. n.
Genus **Geralinura**, Scudder: *G. carbonaria*, Scudder.

Observations.—In these classifications the order Anthracomarti contains heterogeneous elements belonging to the orders Araneæ (*Arthrolycosa*), Ricinulei (*Poliochera*), Anthracomarti (*Anthracomartus*), and, in my opinion, Phalangiotarbi (*Geraphrynus*, *Geratarbus*, *Architarbus*).

In the Pedipalpi the genera referred to the family Geralinuridæ belong to the very distinct sub-orders Amblypygi (*Græophonus*) and Uropygi (*Geralinura*).

4. HAASE, E., Zeitschr. deutsch. geol. Ges., 1890, pp. 629—657.

Order I. SCORPIONES.
Sub-order ANTHRACOSCORPII.
Family EOSCORPIONIDÆ.
Sub-families EOSCORPIONINI, CYCLOPHTHALMI.
Order II. PEDIPALPI.
Sub-order 1. *UROPYGI.*
Family THELYPHONIDÆ.
Genus **Geralinura**, Scudder: *G. carbonaria*, Scudder, etc.
Sub-order 2. *AMBLYPYGI.*
Family ARCHITARBIDÆ.
Genus **Architarbus**, Scudder: *A. rotundatus*, Scudder.
Genus **Geraphrynus**, Scudder: *G. carbonarius*, Scudder.
Order III. CHERNETES.
Genus **Rakovnicia**, Kusta: *R. antiqua*, Kusta.
Order IV. OPILIONES.
Sub-order 1. *PHALANGIOTARBI.*
Family PHALANGIOTARBIDÆ.
Genus **Phalangiotarbus**, nov.: *P. subovalis*, Woodward.
Sub-order 2. *ANTHRACOMARTI.*
Family ANTHRACOMARTIDÆ.
Genus **Anthracomartus**, Karsch: Many species.
Family KREISCHERIIDÆ.
Genus **Kreischeria**, Geinitz: *K. wiedei*, Geinitz.
Family EOPHRYNIDÆ.
Genus **Eophrynus**, Woodward: *E. prestvicii*, Buckland; *salmi*, Stur; *sturii*, sp. n.

Sub-order 3. *PLAGIOSTETHI.*
Family Trogulidæ.
Genus **Poliochera**, Scudder.
Order V. ARANEÆ.
Sub-order 1. *ARTHRARACHNÆ.*
Family Arthrolycosidæ.
Genera **Arthrolycosa**, Harger; **Geralycosa**, Kusta.
Sub-order 2. *TETRASTICTA* (*TETRAPNEUMONES*).
Family Protolycosidæ.
Genus **Protolycosa**, Roemer.
Family Liphistiidæ.
Genera **Eolycosa**, Kusta; **Palaranea**, Fritsch.

Observations.—Haase makes the great advance of recognising the close affinity between the genera he refers to the sub-order Anthracomarti. But *Poliochera* does not belong to the Opiliones, nor in my opinion can the Anthracomarti and Phalangiotarbi be relegated to that order. It seems to me, moreover, that the Phalangiotarbidæ and Architarbidæ belong to the same ordinal group, for which I adopt Haase's name Phalangiotarbi; and this order has no near relationship with the Pedipalpi of the sub-order Amblypygi. As regards the Araneæ, it appears to me that of all the Carboniferous forms *Arthrolycosa* is the most nearly allied to the existing *Liphistius*, and I cannot find any evidence in favour of the creation of a sub-order Arthrarachnæ for *Arthrolycosa* and *Geralycosa;* nor does it appear to me that *Protolycosa*, *Eolycosa*, and *Palaranea* can be referred with any certainty to the Tetrapneumones, none of the existing members of which retain the terga of the opisthosoma.

5. Pocock, R. I., Geol. Mag. [4], vol. ix, 1902, pp. 439—448, 487—493; and vol. x. 1903, p. 408.

Order ANTHRACOMARTI.
Family Anthracosironidæ.
Genus **Anthracosiro**, nov.: *A. woodwardi*, nov.; *fritschii*, nov.
Family Anthracomartidæ.
Genus **Anthracomartus**, Karsch.
Genus **Brachypyge**, Woodward: *B. carbonis*, Woodward; *celtica*, nov.
Family Eophrynidæ.
Genus **Eophrynus**, Woodward: *E. prestvicii*, Buckland; *salmi*, Stur; *sturii*, Haase.
Genus **Kreischeria**, Geinitz: *K. wiedei*, Geinitz.

6. Melander, A. L., Journ. Geol. (Chicago), vol. ii, 1903, pp. 178—184, pls. v, vii.

The author of this paper follows Scudder's classification, and evidently has a very limited acquaintance with Arachnid morphology. He attempts a tabulation

of the genera of the Carboniferous Arachnida of Illinois, adding to those previously characterised a new genus and species, *Hadrachne horribilis*, which certainly belongs to the Phalangiotarbi as defined below.

7. Fritsch, A., Palæozoische Arachniden, Prag, 1904, pp. 5—80.

Order ARANEÆ.
Sub-order ARTHRARACHNÆ, Haase.
Family Arthrolycosidæ.
Genus **Arthrolycosa**, Harger: *A. antiqua*, Harger, etc.
Genus **Protolycosa**, Roemer: *P. anthracophila*, Roemer.
Genus **Geralycosa**, Kusta: *G. fritschii*, Kusta.
Genus **Rakovnicia**, Kusta (= *Eotarbus*, Kusta): *R. antiqua*, Kusta.
Sub-order PLEURARANEÆ, nov.
Family Hemiphrynidæ.
Genus **Hemiphrynus**, Fritsch: *H. longipes, hofmanni*, Fritsch.
Family Promygalidæ.
Genus **Promygale**, Fritsch: *P. bohemica*, Fritsch, etc.
Genus **Perneria**, Fritsch: *P. salticoides*, Fritsch.
Genus **Eopholcus**, Fritsch: *E. pedatus*, Fritsch.
Genus **Pleurolycosa**, Fritsch: *P. prolifera*, Fritsch.
Genus **Brachylycosa**, Fritsch: *B. carcinoides*, Fritsch.
Genus **Pyritaranea**, Fritsch: *P. tubifera*, Fritsch.
Order OPILIONES.
Sub-order OPILIONIDÆ VERI.
Genus **Nemastomoides**, Thevenin: *N. elaveris*, Thevenin.
Genus **Dinopilio**, Fritsch: *D. gigas*, Fritsch.
Sub-order MERIDOGASTRA (= *ANTHRACOMARTI*).
Family Poliocheridæ.
Genus **Poliochera**, Scudder: *P. punctulata*, Scudder.
Family Architarbidæ.
Genus **Geraphrynus**, Scudder: *G. carbonarius, elongatus*, Scudder.
Genus **Architarbus**, Scudder: *A. rotundatus*, Scudder; *subovalis*, Woodward.
Family Anthracomartidæ.
Genus **Anthracomartus**, Karsch: Several species.
Genus **Brachypyge**, Woodward: *B. carbonis*, Woodward; *celtica*, Pocock.
Genus **Anthracosiro**, Pocock: *A. woodwardi, fritschii*, Pocock.
Genus **Eotrogulus**, Thevenin: *E. fayoli*, Thevenin.
Genus **Vratislavia**, Fritsch: *V. silesiaca*, Roemer.
Family Eophrynidæ.
Genus **Eophrynus**, Woodward: *E. prestvicii*, Buckland.
Genus **Stenotrogulus**, Fritsch: *S. salmi*, Stur.
Genus **Cyclotrogulus**, Fritsch: *C. sturii*, Haase.
Genus **Kreischeria**, Geinitz: *K. wiedei*, Geinitz.
Genus **Hemikreischeria**: *H. geinitzi*, Thevenin (= *thevenini*, Fritsch).
Genus **Petrovicia**, Fritsch: *P. proditoria*, Fritsch.
Genus **Adelocaris**, Packard: *A. peruvianus*, Packard.

Order PEDIPALPI.
Family THELYPHONIDÆ.
Genus **Prothelyphonus**, Fritsch: *P. bohemicus*, Kusta; ? *cordai*, Fritsch.
Genus (**Geralinura**, Scudder).
Order SCORPIONES.
Sub-order DIONYCHOPODES.
Family ANTHRACOSCORPII.
Genus **Cyclophthalmus**, Corda: *C. senior*, Corda.
Genus **Microlabis**, Corda: *M. sternbergi*, Corda.
Genus **Isobuthus**, Fritsch: *I. kralupensis*, Thorell and Lindström.
Genus **Eobuthus**, Fritsch: *E. rakovnicensis*, Fritsch.
Genus **Feistmantelia**, Fritsch: *F. ornata*, Fritsch.
Genus **Eoscorpius**, Meek and Worthen: *E. carbonarius*, Meek and Worthen; *anglicus*, Woodward.
Genus **Mazonia**, Meek and Worthen: *M. woodiana*, Meek and Worthen.

Observations.—For reasons published in 1910 I consider that Fritsch's genus *Promygale* is a synonym of *Anthracomartus*; and since the forms he refers to *Hemiphrynus* also belong apparently to the same order as *Anthracomartus*, there is no reason for the retention of his suborder Pleuraraneæ. At all events, whatever these forms may be, they are assuredly not referable to the Araneæ. The other genera assigned to the Araneæ seem to belong to that order, so far as can be judged from the author's figures. As for his order Opiliones, it has already been stated that the Poliocheridæ, Architarbidæ, Anthracomartidæ and Eophrynidæ cannot be relegated to it nor to any single group of Arachnida, whether it be named Anthracomarti or Meridogastra. *Nemastomoides* may be one of the Opiliones, but *Dinopilio*, if figured with an approach to accuracy, should find place in the Araneæ probably. In recognising that *Geraphrynus* and *Architarbus* (including *Phalangiotarbus*) constitute a natural group, Fritsch improves upon Haase's system. As regards the Anthracomartidæ and Eophrynidæ, he practically follows my classification, although he places *Anthracosiro* in the Anthracomartidæ and by so doing drops the family Anthracosironidæ.

Unfortunately, the value of this monograph is lessened by the author's lack of acquaintance with the morphology of recent Arachnida, especially on such points as the constancy of the segmentation of the appendages within ordinal limits. His restorations, therefore, cannot be regarded as correct interpretations of the structure of the fossils.

8. POCOCK, R. I., Geol. Mag. [5], vol. vii, 1910, pp. 505—512.

Reasons are given for concluding that the genera referred by Fritsch to the Pleuraraneæ belong to the Anthracomarti, *Promygale* being a synonym of *Anthracomartus*.

The Phalangiotarbi are retained as a valid group containing the following families and genera with their type species:

Family Phalangiotarbidæ.
Genus **Phalangiotarbus**, Haase: *P. subovalis*, Woodward.
Family Architarbidæ.
Genus **Architarbus**, Scudder: *A. rotundatus*, Scudder.
Genus **Geraphrynus**, Scudder: *G. carbonarius*, Scudder.
Genus **Geratarbus**, Scudder: *G. lacoei*, Scudder.
Genus **Opiliotarbus**, nov.: *O. elongatus*, Scudder.

III.—SYSTEMATIC ACCOUNT OF THE BRITISH SPECIES.

Order SCORPIONES, Latreille.

The Carboniferous Scorpions were formerly assigned by Thorell and Lindström to a special group, Anthracoscorpii, on the supposition that the median eyes were in advance of the lateral eyes, instead of behind them as in recent Scorpions or Neoscorpii. This supposition has no foundation in fact, so far as is known. Perhaps, indeed, the most useful contribution that Fritsch has made to our knowledge of fossil Scorpions, is his discovery that the so-called posterior row of eyes described by Corda in *Cyclophthalmus senior* are in reality tubercles. Fritsch, however, still preserved the name Anthracoscorpii for the Carboniferous species collectively, although justification for this course was not supported by any new definition of the group.

Nevertheless, some of the Carboniferous Scorpions differ from all recent forms in one or two characters of great morphological interest. In the specimen described below from the Coal Measures of Sparth, belonging to the collection of Mr. F. Holt, the sterna of the fourth, fifth, and sixth segments of the opisthosoma end posteriorly in a pair of widely rounded laminate lobes, which are separated by a median angular notch and manifestly overlap the anterior portion of the sterna that succeed them. I am unable to say whether the sternum of the third was similarly constructed; possibly not, since it was evidently covered to a great extent by the pectines of the second sternal plate, which was of large size—much larger, indeed, than in any recent species. Moreover, the basal segments of the legs of the fourth pair do not apparently abut against the sternal plate of the prosoma, as in existing Scorpions, but against the sides of the genital operculum, a feature quite unknown in existing species, in which the coxæ of the third and fourth legs are united to form a wedge-shaped skeletal piece diverging obliquely backwards and outwards from the sternum of the prosoma. The figures published by Fritsch of the types of *Eobuthus rakovnicensis* and of *Isobuthus kralupensis* seem to agree

with Mr. Holt's example in the mode of attachment of the coxæ in question; but even if in these specimens the sclerites on each side of the genital operculum do not, as figured by Fritsch, belong to the fourth leg, the presence of sclerites on each side of this plate is a feature unknown in modern Scorpions, where the operculum is the sole trace of appendages of the first segment of the opisthosoma. These sclerites, therefore, are of great morphological interest, whatever interpretation be put upon them. It is possible, indeed, that they must be compared with the lateral plates of the genital segment present apparently in the Silurian Scorpion I described as *Palæophonus hunteri*[1] (Quart. Journ. Micr. Sci., 1902, p. 291, pl. 19).

The peculiarities above described do not, however, exist in all Carboniferous Scorpions. In one of the specimens described below under the heading *Anthracoscorpio buthiformis* the sternum of the prosoma, the coxæ of the third and fourth legs, and the genital operculum appear to be in structural agreement with the same pieces in recent Scorpions; and there is no evidence that they are differently arranged in the example in the British Museum which I identify as *Anthracoscorpio sparthensis*. The species described by Peach as *Eoscorpius euglyptus* and *glaber* also seem to fall into line with recent types in the particulars named; and Fritsch's figure of *Cyclophthalmus senior* is susceptible of the same interpretation.

Hence it seems that the Carboniferous Scorpions are divisible into two groups, one of which is inseparable on broad structural lines from recent species. The terms "Anthracoscorpii" and "Neoscorpii" cease, therefore, to be applicable. Although it is impossible to assign all the described Carboniferous species to one or the other of these groups, it appears to me that the characters by which the two are distinguished are too important and interesting to be ignored in a classification of this order. I propose, therefore, the term **Lobosterni** for those with bilobed, posteriorly-laminate sternal plates on the opisthosoma and skeletal plates, whether belonging to the fourth leg or not, on each side of the genital operculum; and the term **Orthosterni** for those agreeing apparently with recent Scorpions in the structure of the plates in question. In this monograph *Eobuthus* belongs to the Lobosterni, and *Cyclophthalmus*, *Archæoctonus* and *Anthracoscorpio* to the Orthosterni, *Palæomachus* being of doubtful position. Of exotic genera, *Microlabis* seems to be referable to the Orthosterni, *Isobuthus* to the Lobosterni, while *Eoscorpius* and *Mazonia* cannot be classified. Probably a special group should be created for *Mazonia* if the extant restoration of the genus be accurate.

The determination of the genera has been a matter of great difficulty, because I have been compelled to rely mostly upon the figures and descriptions published by Fritsch, whose acquaintance with the morphology of recent Scorpions is

[1] According to Mr. R. Dunlop (Ann. Glenfield Rambler, No. 2, 1898, pp. 60—64) this Silurian Scorpion was named *Palæophonus caledonicus* by Dr. Peach. I do not know where Dr. Peach described it under that name; and possibly Mr. Dunlop, writing from memory, has confused this species with *Glyptoscorpius caledonicus*. Provisionally, therefore, I retain *hunteri* as the specific designation.

evidently not sufficiently intimate to inspire confidence in the accuracy of his interpretations of the fossils. This fact, coupled with the imperfect preservation of many specimens, makes the classification of the British species, put forward in the following monograph, provisional in many respects. I hope, at least, that it may help those who come after me to improve upon the system here proposed.

All the British species of Carboniferous Scorpions hitherto described have been referred to the genus *Eoscorpius*, Meek and Worthen, which was based upon a single species, *E. carbonarius*, from Mazon Creek, Illinois (Amer. Journ. Sci., ser. 2, vol xlv, 1868, p. 560). The chelæ are unknown; but the last tergal plate of the abdominal portion of the opisthosoma is of quite unusual length as compared with the other terga and with the carapace, which appears to be short. The second and third caudal segments, moreover, are long, being much longer than wide, suggesting that the entire tail must have been at least four times, and was very probably five times, as long as the carapace. Since none of the British species in which these skeletal pieces are known, agree with *Eoscorpius carbonarius*, they cannot be assigned to the genus. Scudder has suggested that *Mazonia woodiana*, from the same beds as *Eoscorpius carbonarius*, may be synonymous with it. This view, however, cannot on the evidence be entertained; because, if correctly drawn, the former is unique in having either a segmented carapace or eight dorsal shields, possibly, indeed, nine, according to Fritsch, between the head-shield and the tail. The ocular tubercle, moreover, is situated almost at the anterior border of the carapace, and the humerus and brachium of the chela are remarkably long and slender. Since none of the British species present these characters, *Mazonia*, like *Eoscorpius*, need not be further considered in this monograph.

The European species, excluding those described by Dr. Peach from Scotland which are omitted from Fritsch's monograph, are referred by this author to the following genera: *Cyclophthalmus*, Corda; *Microlabis*, Corda; *Isobuthus*, Fritsch; *Eobuthus*, Fritsch; *Feistmantelia*, Fritsch; and *Eoscorpius*, M. and W. *Anthracoscorpio*, Kusta, is rejected by Fritsch as based upon an immature specimen of *Eobuthus*; and *Eoscorpius* is included for the reception of the species described by Dr. Woodward as *E. anglicus*.

Microlabis, possessing only one species, namely, *M. sternbergi*, Corda, differs from all the other European genera, so far as is known, in the structure of the chelæ, which have the brachium long, parallel-sided, and prismatic, the hand or manus short and very narrow, without any bulge on its inner edge, and with no concavity at the base of the immovable digit, which, like the movable, is long, stout, and straight, the two resembling the blades of scissors, the movable being more than half as wide as the hand. This genus, therefore, may be set on one side. So also must *Feistmantelia*, based upon a single character, the tuberculation of the pectines. This is probably the same feature as that described by Dr. Peach

in several Scottish species, referable to more than one genus, as "embossed scale-like pattern." It is not known whether *Cyclophthalmus* possessed this character or not.

A glance at Peach's figures of Scottish Carboniferous Scorpions shows that at least two genera must be admitted. One of the species, described as *Eoscorpius euglyptus*, has the large cheliceræ and stout chelæ of *Cyclophthalmus*, and I am unable to say that it does not belong to that genus. *Eoscorpius glaber*, on the contrary, is a totally different form; and it also differs in the shortness of its legs and the structure of its chelæ from all the other European genera where these organs are known. For this I propose a new generic name, *Archæoctonus*. A third British genus seems to be represented by the species described as *Eoscorpius anglicus* by Dr. Henry Woodward. The remaining British species are, for reasons discussed below, assigned to the genera *Anthracoscorpio*, Kusta, and *Eobuthus*, Fritsch.

The subjoined table shows the main features by which these genera may be tentatively distinguished from each other:

a. Hand of chelæ wide and oval, greatly exceeding the brachium in width; fingers very short, the movable about equal to the width of the hand. [Caudal segments apparently very short and broad and not sensibly increasing in length posteriorly; legs and sterna unknown.] . . . . . *Palæomachus.*

a'. Hand of chelæ wide or narrow, but at most only exceeding by a little the width of the brachium; fingers, except perhaps in *Eobuthus*, long, the movable much longer than the width of the hand.

b. Legs exceedingly short, the fourth, when extended, not reaching the end of the abdominal portion of the opisthosoma; its femur much shorter than the carapace. [Sterna of abdomen with straight posterior borders; coxæ of third and fourth legs apparently abutting against the sternum of the prosoma.] . . . . . *Archæoctonus.*

b'. Legs of normal length, the fourth, when extended, surpassing the posterior end of the abdomen; its femur about as long as the carapace.

c. Coxæ of third and fourth legs abutting against the sternum of the prosoma; the posterior border of the sterna of the fourth, fifth, and sixth segments of the opisthosoma straight or nearly so.

d. Chelæ heavy and massive, with stout, strong fingers. *Cyclophthalmus.*

d'. Chelæ comparatively light and slender, with thin fingers. *Anthracoscorpio.*

c. Coxæ of legs of third pair abutting against the sternum of the prosoma, those of the fourth against the genital operculum; sterna of fourth, fifth, and sixth segments of opisthosoma markedly bilobate and laminate posteriorly. . . . *Eobuthus.*

Genus **EOBUTHUS,** Fritsch.

1904. *Eobuthus*, A. Fritsch, Palæoz. Arachn., p. 72 (in part).

This genus was based by Fritsch on two Carboniferous Scorpions from Bohemia, one in the museum at Prague, the other in the British Museum. Both were named *E. rakovnicensis.* The specimen at Prague I have not seen; but if Fritsch's restoration of it approaches accuracy, the fossil cannot be assigned to the same genus as that in the British Museum. One great difference between them lies in the structure of the chelæ, the movable digit in the Prague specimen being much shorter than the length of the hand or manus, and only a little exceeding its breadth,whereas in the British Museum specimen the length of the movable digit greatly exceeds both the length and breadth of the hand. Moreover, the structure of the sternal surface of the prosoma in the Prague specimen is quite abnormal in the circumstance, that the coxæ of the legs of the last pair appear to abut against the genital operculum, those of the third pair alone running up to the sternal plate of the prosoma. In the British Museum specimen, on the contrary, so far as I can judge, the coxæ of these appendages are quite normal in their mode of attachment to the body. This specimen, in fact, appears to be a normal Scorpion in every respect, except that the sternal plates of the fifth and sixth segments of the opisthosoma are seemingly slightly lobate posteriorly with a shallow median notch.

Since the diagnosis of *Eobuthus* was taken, mainly, at all events, from the specimen at Prague, I propose to regard that specimen as the type of *E. rakovnicensis.* Different names, both generic and specific, must therefore be found for the example in the British Museum.

According to Fritsch the generic name *Anthracoscorpio* was given by Kusta to a Scorpion named *A. juvenis*, which is the young of *Eobuthus rakovnicensis.* If this be so Fritsch had no right, according to the accepted rules of nomenclature, to assign new generic and specific names to the fossils in question. But the figure he published of the type of *Anthracoscorpio juvenis* cannot, according to his interpretations, represent the young of the typical *Eobuthus rakovnicensis* as here understood. It may, however, represent the young of the form in the British Museum. At all events the two specimens are likely enough to be congeneric. I propose, therefore, to assign the specimen in the British Museum to the genus *Anthracoscorpio*; and since I cannot, on the available evidence, separate this specimen specifically from the type of *Eoscorpius sparthensis* (*cf. infra*, p. 20), it may take for the time being the name *Anthracoscorpio sparthensis.*

I have seen only one British Scorpion which appears to agree with the type of *Eobuthus rakovnicensis* in the mode of attachment of the posterior limbs to the body. This I propose to name as follows:

Eobuthus holti, sp. nov. Plate II, fig. 2; Text-figure 1.

The sternum of the prosoma is semi-elliptical, convex, rounded in front and truncated behind. Abutting against it on each side there is a large coxal segment belonging to the legs of the third or fourth pairs. Following the sternum there is a conspicuous bivalved genital operculum resembling in a general way that of recent Scorpions; and on each side of this there appears to be a segment (or segments) of a limb, which does not, however, resemble the coxa of the fourth leg in recent Scorpions, which always abuts against the sternum of the prosoma. If it does not belong to the fourth leg, I can only suggest that it represents the external ramus of a pair of appendages belonging to the genital segment, the

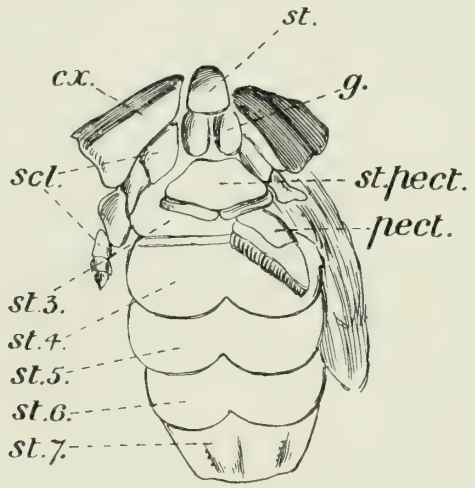


Fig. 1.—*Eobuthus holti*, sp. n.; partially restored and slightly magnified from the type specimen.—Coal Measures; Sparth, near Rochdale. F. Holt Collection. *cx.*, coxa of 3rd leg, possibly fused coxæ of 3rd and 4th legs; *g.*, genital operculum; *pect.*, one of the pectines, its exact structure being doubtful; *scl.*, sclerites abutting against genital operculum and probably representing either the basal segments of a leg of the 4th pair or the lateral ramus of the appendage of the 1st somite of the opisthosoma; *st.*, sternum of prosoma; *st. pect.*, sternum of pectinal somite; *st.* 3 to *st.* 7, st rna of the 3rd to the 7th somites of the opisthosoma, the exact shape of the 3rd being doubtful.

two halves of the genital operculum being the internal rami. In this connection it must be remembered that the genital operculum of *Limulus polyphemus* consists of a pair of inner and a pair of outer branches or rami. Behind the genital operculum follows a moderately large plate, much wider behind than in front. This is the sternum to which the pectines are attached. One of the latter attached to its posterior border is traceable, but the details of its structure, apart from its shape and the presence of numerous small teeth, are too faint to figure or describe with assurance.

Of the five posterior sterna of the abdominal portion of the opisthosoma, the first appears to be rather small and to be overlapped by the sternum and pectines of the segment in front of it. I cannot find evidence that its posterior border is bilobed; but the posterior borders of the three succeeding sterna are markedly

laminate and bilobed; the lobes are semicircular and considerably overlap the anterior portion of the sterna behind them. No such laminate lobes are found on the last sternal plate of the abdominal portion of the opisthosoma; this sternum is exactly like that of recent Scorpions and has a pair of abbreviated granular crests. The interest of these laminate lobes on the sterna which belong morphologically to the fourth, fifth and sixth segments of the opisthosoma, lies in their general resemblance to the gill-bearing appendages of the same segments in *Limulus*. I can find no trace of stigmata upon these sterna; hence I suppose that the respiratory lamellæ lay beneath them as they do in *Limulus*. In possessing these lobate sternal plates, the Scorpion now described is more like *Limulus* than is the Silurian Scorpion *Palæophonus*; and it supplies one more valuable link in the chain of evidence pointing to affinity between the Scorpions and Xiphosuræ.

The fragments of limbs of the prosoma that remain resemble those of recent Scorpions, and offer nothing specially worthy of comment.

Measurements in mm.—Total length from anterior end of sternum of prosoma to posterior end of last abdominal segment of opisthosoma about 41; length of coxa abutting against sternum 11; length of the sternum 4, width about 3·5; width of genital operculum 4·5, length 3·5; length of sternum of pectinal segment 4, anterior width 4, posterior width 9·5; length of pecten about 9; width of penultimate sternal plate of abdomen 21; length at the side nearly 9.

A single specimen from Sparth, near Rochdale, in the collection of Mr. F. Holt.

This specimen shows the ventral surface of the abdominal portion of the opisthosoma, part of the ventral surface of the prosoma, and portions of some of the limbs.

So far as can be judged, this specimen differs from that of *E. rakovnicensis* in being larger and in having the sternal plate of the pecten-bearing segment relatively much larger. In *E. rakovnicensis* the length from the sternum of the prosoma to the end of the abdominal portion of the opisthosoma is probably about 34 mm. In *E. holti*, the same area, although contracted, is 41 mm.; and in the latter the length of the sternum of the prosoma is about equal to that of the sternal plate of the pectines, while it is much less than half its posterior width. In *E. rakovnicensis*, on the contrary, the sternum of the prosoma is longer than the sternum of the pectines and half its posterior width. I have no doubt that many more differences will be discovered when better material is available for examination.

I provisionally refer to this species a specimen from the Shipley claypit in Dr. Moysey's collection. It consists of the abdominal portion of the opisthosoma, showing the terga, some of the sterna, and a considerable portion of one of the legs of the last pair. The segments, however, are apparently telescoped to a considerable extent, thus appearing to be very much shorter than they are in reality. The tergum and sternum of the last segment of the abdominal portion

are wonderfully well preserved. The tergum bears many scattered coarse granules, has coarsely granular lateral margins, and a pair of coarsely granular longitudinal keels lying slightly obliquely, each keel being rather nearer to the lateral edge than to its fellow of the opposite side; the sternum, on the other hand, is smooth except for two coarsely granular longitudinal keels, one on each side of the middle line. The sterna in front of this are not sufficiently well preserved for me to state definitely that they were laminate and lobate posteriorly as in Mr. Holt's specimen, but there are indications that this was so.

Measurements in mm.—Total length of abdominal portion of opisthosoma (contracted) 28; width of the same (distended) 22; width of tergum of the last segment 17, of sternum 20; length of femur of fourth leg 13, of patella 11, of tibia 11.

According to Fritsch's restoration, the type of *Isobuthus*, *I. kralupensis*, Thorell and Lindström, resembles *Eobuthus rakovnicensis* in the mode of attachment of the coxæ of the legs of the third and fourth pairs to the body. It also appears to have the posterior margin of the sterna of the fourth, fifth and sixth segments of the opisthosoma bilobate and mesially notched, as in Mr. Holt's specimen described above. On the evidence, therefore, *Isobuthus* must be assigned to the same group of Scorpions as *Eobuthus;* but according to the figures published by Fritsch, *Isobuthus* has tolerably normal chelæ with the movable finger greatly exceeding in length both the length and breadth of the hand. Since the chelæ are unknown in Mr. Holt's specimen, it is possible that the species it represents may be congeneric with *Isobuthus kralupensis.*

Genus **PALÆOMACHUS**, nov.

1876. *Eoscorpius*, H. Woodward (in part), Quart. Journ. Geol. Soc., vol. xxxii, p. 58, pl. viii.

Generic Characters.—Hand broad and oval, its width greatly exceeding that of the brachium, its length exceeding that of the fingers, which are short and in contact when closed, the length of the immovable digit about equal to the width of the hand. Caudal segments short and stout, apparently about as long as they are wide or high, and not progressively increasing in length from the base to the tip of the tail.

Type Species.—Eoscorpius anglicus, H. Woodward.

Palæomachus anglicus (H. Woodward). Text-figure 2.

1876. *Eoscorpius anglicus*, H. Woodward, Quart. Journ. Geol. Soc., vol. xxxii, p. 58, pl. viii, fig. 3 (type), also figs. 1 and 2.

The type species of this genus was based upon three specimens, namely, the extremity of a chela from Mansfield in Nottinghamshire, five caudal segments

from the same locality and horizon, and an entire tail from the Sandwell Park Colliery, Birmingham. It is not unlikely that the tail from Mansfield belonged to an example of the same species as the owner of the chela, from the same locality; and this tail is structurally closely similar to the one from Birmingham. Dr. Woodward, therefore, was perfectly justified in referring the three to the same species. In this I propose to follow his example until evidence to the contrary is forthcoming. Nevertheless, in view of the possibility of the chela and caudal segments from Mansfield belonging to different species, perhaps to different genera, it seems advisable to select one of the specimens as the type of the species. I select, therefore, the chela, because the species may be distinguished at once from all other Carboniferous Scorpions in which the chela is known, by the shape and proportions of the segments of this appendage.

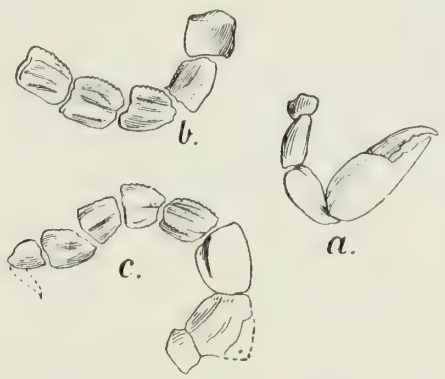


Fig. 2.—*Palæomachus anglicus* (Woodward); copied from Quart. Journ. Geol. Soc., vol. xxxii, pl. viii. *a.*, chela from Mansfield; *b.*, five caudal segments from Mansfield; *c.*, entire tail from Sandwell Park.

The only Carboniferous Scorpion described with fingers as short as in *P. anglicus* is the type of *Eobuthus rakovnicensis*, Fritsch. Assuming that the figure and description published by Fritsch are correct, *P. anglicus* cannot be assigned to the genus *Eobuthus*, because in the type species of the latter the hands are much longer than the digits, and a little narrower than the brachium.

Genus **ARCHÆOCTONUS**, nov.

1883. *Eoscorpius*, Peach (in part), Trans. Roy. Soc. Edinb., vol. xxx, p. 398.

Generic Characters.—Distinguishable, so far as is known, from all other genera of Carboniferous, as well as of recent Scorpions, by the extreme shortness of the legs, those of the fourth pair, when extended, not nearly attaining the posterior extremity of the abdominal portion of the opisthosoma (pre-abdomen). The individual segments of the legs are not very unequal in length, and the femur of the fourth is much shorter than the carapace. The hand of the chela is small,

narrow, scarcely at all inflated, about the width of the preceding segment (brachium), and the back of the hand is only about half the length of the movable digit; the digits are straight and in contact when closed, and the immovable is markedly bent at the tip.

Type Species.—Eoscorpius glaber, Peach.

In the structure of its post-oral appendages this Scorpion is very peculiar. Judging from Peach's figure the chelæ differ structurally from those of all known species, living or extinct, especially in the straightness of the fingers, the narrow, nearly parallel-sided, but short hand, and the extreme shortness of the brachium. The possibility of Peach having made a mistake over this last feature in his restoration has influenced my decision to leave it out of the diagnosis It must not, however, on that account be forgotten, as might well be the case seeing that no mention of the peculiarity is to be found in the text. Nor was the author

Fig. 3.—*Archæoctonus glaber* (Peach); copied from Trans. Roy. Soc. Edinb., vol. xxx, pl. xxii, fig. 2 *b*, nat. size.—Lower Carboniferous; Langholm. A. Macconochie Collection.

struck, apparently, by the anomalous structure of the ambulatory limbs, which his drawings show so well. Another interesting feature not referred to is the presence of a single pedal spur on the terminal joint of the legs, a feature in which this Scorpion resembles the genera belonging to the existing family Scorpionidæ.

Archæoctonus glaber (Peach). Text-figure 3.

1883. *Eoscorpius glaber*, B. N. Peach, Trans. Roy. Soc. Edinb., vol. xxx, p. 400, pl. xxii, figs. 2—2 *l*.

Integument smooth, without tubercles. Total length probably about 50 mm., carapace 9 mm., last abdominal + first caudal segment 7 mm., movable digit 8 mm., back of hand 3 mm., width of hand 4 mm., of brachium 3 mm.

Based on two specimens, the type from near the Cementstone Group of the Lower Carboniferous, Langholm, Dumfriesshire, the other from the Calciferous Sandstone Series at Redhall, near Slateford, Edinburgh.

Archæoctonus tuberculatus (Peach).

1883. *Eoscorpius tuberculatus*, B. N. Peach, Trans. Roy. Soc. Edinb., vol. xxx, p. 398, pl. xxiii, figs. 8—8 *h*.

Possibly not belonging to the genus *Archæoctonus*, since the ambulatory appendages are unknown and the chelæ unfigured and indifferently described. Specifically *A. tuberculatus* differs from *A. glaber* in having the terga of the abdominal portion dotted with small tubercles, and ornamented with two rows of larger tubercles along the posterior margin.

Total length supposed to be about 62 mm.

This species was based upon several pieces obtained from the Coal Measures at Blair Point, near Dysart, and from the Calciferous Sandstone Series from Redhall and Cramond, near Edinburgh.

Genus **CYCLOPHTHALMUS**, Corda.

1835. *Cyclophthalmus*, A. J. C. Corda, Verh. Ges. Mus. Böhm., p. 36.
1904. *Cyclophthalmus*, A. Fritsch, Palæoz. Arachn., pp. 65—68.

For reasons already given (p. 12) this genus is here recorded for the reception of the Scorpion described by Peach as *Eoscorpius euglyptus*.

Cyclophthalmus euglyptus (Peach). Text-figure 4.

1883. *Eoscorpius euglyptus*, B. N. Peach, Trans. Roy. Soc. Edinb., vol. xxx, pp. 402—404, pl. xxii, figs. 3 to 3 *d*.

This species was based on a single specimen obtained near the base of the Cementstone Group, Calciferous Sandstone (Lower Carboniferous), near Langholm, Dumfriesshire, in Scotland. The ventral surface of the prosoma, with complete cheliceræ and chelæ and incomplete walking legs, is exposed, the structure of the coxæ, sternum, genital operculum and pectines being well shown.

The cheliceræ and chelæ are large, the chelæ being heavy and massive; the hand is ovally elongate in profile view, considerably longer than wide, and a little wider than the brachium; the fingers are arcuate and basally lobate, the movable being but little longer than the back of the hand. The sternum is pentagonal; the pectines are large and ornamented with squamiform sculpture.

Judging from Peach's restoration the measurements in mm. of the chelæ are as follows:

Length of humerus 13, of brachium 11, of back of hand 12, of movable finger 12·5; width of hand 7·5, of brachium 7.

C. senior, the type of the genus *Cyclophthalmus*, certainly differs from *C. euglyptus* in having the hand shorter, the movable digit being much longer than the back of the hand. So far as size is concerned, the two Scorpions are much alike.

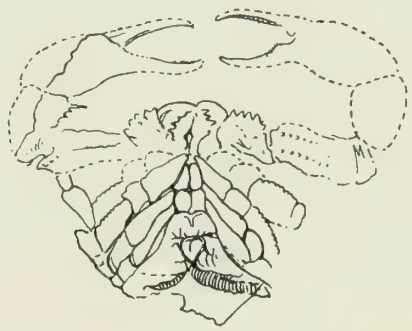


Fig. 4.—*Cyclophthalmus euglyptus* (Peach); copied from Trans. Roy. Soc. Edin., vol. xxx, pl. xxii, fig. 3 *a*, nat. size.—Lower Carboniferous; Langholm. A. Macconochie Collection.

The length of *C. senior*, without the tail, is about 44 mm.; with the tail it would be probably between 80 and 90 mm.

Genus **ANTHRACOSCORPIO**, Kusta.

1888. *Anthracoscorpio*, J. Kusta, SB. k. böhm. Ges. Wiss., p. 202.
1904. *Anthracoscorpio*, A. Fritsch, Palæoz. Arachn., p. 75.
1904. *Eobuthus*, A. Fritsch, Palæoz. Arachn., p. 72 (in part).
1904. *Eoscorpius*, W. Baldwin and W. H. Sutcliffe, Quart. Journ. Geol. Soc., vol. lx, pp. 395—398.

Characters as enumerated above (p. 12).

Anthracoscorpio sparthensis (Baldwin and Sutcliffe).

1904. *Eobuthus rakovnicensis*, A. Fritsch, Palæoz. Arachn., p. 74, text-fig. 91, and pl. xii, figs. 1—3 (*nec* text-figs. 90 and 92, and pl. xii, figs. 1 and 2).
1904. *Eoscorpius sparthensis*, W. Baldwin and W. H. Sutcliffe, Quart. Journ. Geol. Soc., vol. lx, p. 396, fig. 2.

Messrs. Baldwin and Sutcliffe appear to have compared the type of *A. sparthensis* with the example in the British Museum described by Fritsch as *Eobuthus rakovnicensis*. On the evidence I do not agree that the two specimens can be regarded as specifically distinct; nevertheless, for reasons given above

(p. 13) the name *sparthensis* must be retained. The characters relied upon for separating *sparthensis* as a distinct species are : (1) A difference of 1 mm. in total length ; (2) a shorter and narrower abdomen ; (3) shorter caudal segments ; (4) a narrower hand.

Since Scorpions vary in size both individually when adult and according to age, the first character clearly has no value. The second may be similarly dismissed because the length and girth of the abdomen vary enormously in accordance with the degree of repletion of this region with food or embryos ; it is usually, moreover, narrower and shorter in males than in females. The third character appears to me to have no foundation in fact, so far as I can judge from the rough sketch of the type of *E. sparthensis* which I made for Mr. Baldwin when he asked my advice about the specimen, and which he reproduced in his paper. Finally, as regards the hand of *E. sparthensis*, its apparent narrowness is simply due to the fact that it is axially rotated to a greater degree so that the movable digit is concealed by the immovable. Hands of scorpions are always narrower in this position than when resting so as to display the movable digit from the dorsal side.

The type of *E. sparthensis*, measuring about 74 mm. in total length, is imbedded in an ironstone nodule from the Middle Coal Measures of Sparth Bottom, near Rochdale in Lancashire. It is in the Manchester Museum. The Bohemian example in the British Museum measures about 75 mm. According to my observations upon this specimen, Fritsch's drawings of it on pl. xii of his monograph are inaccurate, notably, for example, in the curvature of the immovable digits of the chelæ.

Anthracoscorpio dunlopi, sp. nov. Plate I, fig. 1 ; Text-figure 5.

Of large size, approximately equalling the length of the largest known species of the order. Carapace approximately as long apparently as the humerus or brachium or movable digit of the chela, and not very much shorter than the sum of the first and second caudal segments. Its exact length, however, is uncertain, because the posterior border is not defined, and the portions I interpret as the frontal lobes may possibly be the basal segments of the cheliceræ. Since, however, these lobes are sculptured with longitudinal grooves, and the basal segments of the cheliceræ in recent Scorpions are polished so as to slide beneath the carapace, I judge the pieces in question to belong to the carapace. If this be correct the anterior border is emarginate, with a median notch from which a well-defined furrow-like groove extends backwards to the ocular tubercle, becoming shallower posteriorly. The tubercle is elongate, pointed behind and situated nearly in the middle of the carapace. The two eyes are indistinctly defined. No trace of lateral eyes has been preserved. Behind the tubercle a groove extends backwards towards the posterior border. On the left side of the posterior half of the

carapace a longitudinal groove runs obliquely backwards and inwards, its anterior extremity starting at a point nearly on a level with the posterior end of the ocular tubercle. The posterior portion of the carapace on each side of the median groove is distinctly but irregularly granular.

The abdominal terga are granular, but there is no evidence that they possessed either median or lateral crests. They appear to be perfectly normally constructed. The posterior borders of the first, second and third are not clearly

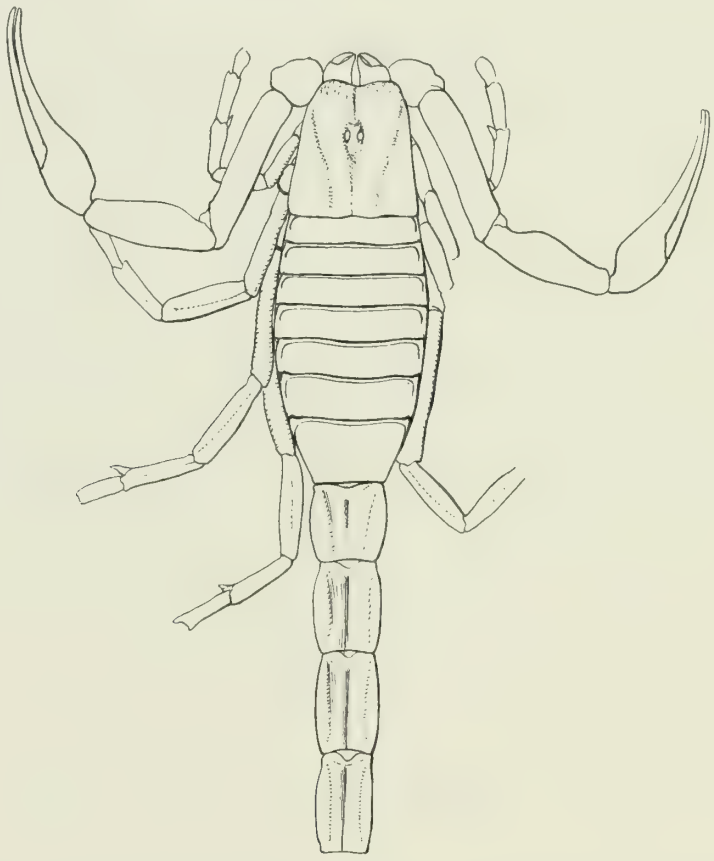


Fig. 5.—*Anthracoscorpio dunlopi*, sp. n.; suggested restoration of the type specimen, approximately nat. size, with the abdominal somites contracted.—Upper Coal Measures; Drumgray. R. Dunlop Collection.

defined; those of the fourth, fifth, sixth and seventh are more distinct, especially that of the sixth. The seventh tergal plate is a little longer than half the length of the carapace, its posterior width exceeding half its anterior width.

Of the tail only the anterior four segments and a portion of the fifth are preserved. It is nearly parallel-sided, the first segment being a little wider than the second, and the second than the third and fourth, the two last being approximately equal in width. The second, third, and fourth segments are almost equal in length, being a little longer and a little narrower than the first. The structure of the segments is normal, each being marked in the middle line by a shallow groove; the superior crests are small and distinctly and evenly granular, but in no

sense denticulated; the supero-lateral crests are similarly granular, and granules are irregularly scattered over the areas between the crests.

The cheliceræ are not well preserved, no details of the dentition being decipherable; but the movable digit appears to be strongly arcuate.

The chelæ are long and slender, somewhat recalling those of *Chelifer cancroides*. The humerus and brachium are subequal in length, and both, broadly speaking, about four times as long as wide. No trace of crests or granulation is preserved. The manus is slender and oval, its width being a little greater than that of the brachium, and little more than half the length of the back of the manus. The digits are slender, normally arcuate, the movable being about as long as the carapace, brachium, or humerus.

Portions of all the legs are preserved, showing the normal structure. Evidence for the existence of tibial spurs is to be found on the fourth and fifth legs, as in many genera of existing Buthidæ; but there also appears to be one on the first leg —a character not present in any recent species of the order. On the second leg of one side a pedal spur is also preserved. The femora, patellæ, tibiæ and protarsi are crested, and the femora at least are beaded with granules along their upper and lower edges. The claws are not preserved.

Approximate Measurements in mm. of Type Specimen.

Length of carapace	. . .	20?			
„ abdomen	. . .	40			
„ caudal segments 1 to 4	. .	50			
„ entire tail probably not less than		70			
„ entire animal „ „ „		130			
„ first caudal segment	. .	10·5	width of same	.	11
„ second „ „	. .	13	„ „	.	10·5
„ third „ „	. .	13	„ „	.	10
„ fourth „ „	. .	13	„ „	.	10
„ humerus	. . .	21			
„ brachium	. . .	20	width of brachium	.	5
„ back of the hand	. .	9	„ of hand	.	6
„ movable digit	. .	20			

In the above-given table the probable total length of the tail has been guessed from the length of the fourth segment, 20 mm. being allowed for the fifth segment and the vesicle, which are not preserved. These two missing segments were probably not less, and may have been more than the amount supposed, since the fifth caudal segment is never shorter and is usually longer than the fourth in living Scorpions.

The type and only known specimen of this species is contained on the two pieces of a split shale from the Upper Coal Measures of Drumgray, near Airdrie, in Scotland. It is in the possession of Mr. R. Dunlop, to whom I have dedicated

the species in acknowledgment of his kindness in sending it to me for description.

The type of this species approaches twice the length of the type specimen of *A. sparthensis*. It also differs in its proportions, the tail being longer and the manus of the chela narrower. In *A. sparthensis*, for instance, the first four segments of the tail only exceed twice the length of the carapace by about one-third of its length, the carapace being approximately as long as the first and second segments together, whereas in *A. dunlopi* the first four caudal segments exceed twice the length of the carapace by at least half its length, and the carapace is distinctly shorter than the first two caudal segments so far as can be judged. In *A. sparthensis*, again, the width of the manus is nearly half the length of the movable digit, while in *A. dunlopi* it is rather less than one-third of the length. The smaller size of the example of *A. sparthensis*, coupled with the shorter tail, might be attributed to immaturity, were it not that the two known examples of this species are approximately equal in size and have all the appearances, judging from the firmness of the exoskeleton, of being adult. Moreover, the hands of the chelæ in young Scorpions are relatively narrower than in full-grown examples. Hence their greater relative width in *A. sparthensis* as compared with *A. dunlopi* is quite irreconcilable with the conclusion that the former specific name has been assigned to young examples of the latter species. For these reasons I have not hesitated to describe Mr. Dunlop's specimen as an example of a distinct species. This specimen was for some time in the possession of Dr. Peach, who made a drawing of it in close agreement with my own restoration. This drawing, accompanied by a short account, was published by Mr. Dunlop in the Annals of the Glenfield Rambler, No. 2, pp. 60—64, 1898, but no name appears to have been assigned to the specimen.

Anthracoscorpio buthiformis, sp. nov. Plate I, fig. 2; Plate II, fig. 1; Text-figures 6—8.

Dorsal integument finely and closely granular; neither the carapace nor the first six terga of the opisthosoma visibly keeled. Carapace about as long as its posterior width, its length a little exceeding that of the first and second caudal segments together, and about equal to that of the second and third, and to the fifth and half the fourth. The ocular tubercle in the middle of its anterior half; a shallow median longitudinal groove running from it posteriorly and expanding and deepening just before the posterior border; the anterior border of the carapace apparently slightly convex, perhaps with a small median excrescence; the posterior border slightly convex in the middle. Terga of the abdominal portion of the opisthosoma showing the anterior elevated rim, this region, thus distended, a little more than twice the length of the carapace. Tail, when complete, no

doubt a little more than three times the length of the carapace, for without the post-anal spine it is about twice and a half times the length; segments one to five gradually increasing in length; the first segment the widest, much wider than long, the second and third also wider than long, the fourth about as long as wide, the fifth longer than wide; the upper surface of the segments normally and strongly keeled, the superior keels converging on segments one to four, almost parallel on segment five; the upper surface hollowed between the superior keels, which, like the superior lateral keels, are granular. Chelæ slender, humerus and brachium each much shorter than the carapace, which is slightly shorter than

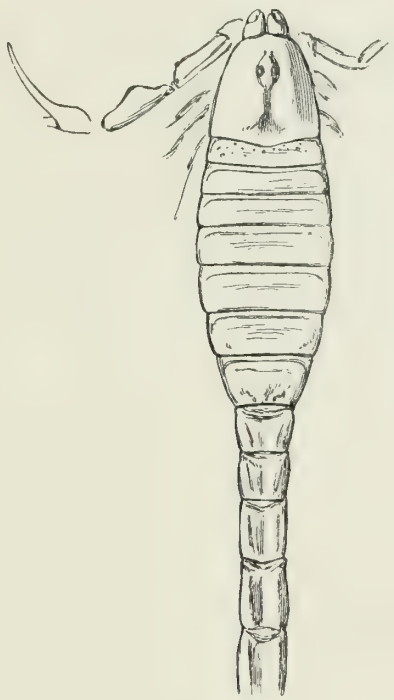


Fig. 6.—*Anthracoscorpio buthiformis*, sp. n.; four times nat. size.—Coal Measures; Sparth, near Rochdale. W. A. Parker Collection.

the manus with its digits. Manus slender, apparently keeled above and slightly wider than the brachium.

Measurements in mm.—Total length, exclusive of post-anal spine and cheliceræ, 21; length of carapace 3·5, of abdominal portion of opisthosoma 8; of caudal segments one to five about 10; length of first caudal segment 1·3, of second 1·6, of fourth 2, of fifth 2·5; width of first 2·5, of second 2 +, of fifth 2 −; length of manus and digits about 4.

Coal Measures of Sparth, near Rochdale.

Type above described in the Collection of Mr. W. A. Parker (Pl. II, fig. 1).

I have selected this specimen as the type because it shows the structure of the dorsal surface very clearly. Only fragments of the legs are preserved, but the details of the chelæ of the left side can be deciphered.

In addition to this specimen I have seen several examples from Dudley, which, in the absence of satisfactory proof of their distinctness from each other and from the type, I provisionally refer to this species. With the exception of one small specimen, which is immature if conspecific with the rest, I judge these specimens to be mature from the apparent thickness of the exoskeleton. The species therefore differs from *A. sparthensis* by its much smaller size. In the type specimen also the tail is shorter, the carapace being half the length of the first four caudal segments, whereas in *A. sparthensis*, as testified by the type, the carapace is less than half that length.

I subjoin the following notes on the examples from the Dudley Coalfield:

(1) Specimen in Mr. Madeley's Collection showing the chelæ, the trochanters, femora, and part of the patellæ of the leg of the first, second, and third pairs, the

Fig. 7.—*Anthracoscorpio buthiformis*, sp. n.; about three times nat. size.—Coal Measures; Coseley, near Dudley. W. Madeley Collection.

Fig. 8.—*Anthracoscorpio buthiformis*, sp. n.; three times nat. size.—Coal Measures; Coseley, near Dudley. Wheelton Hind Collection.

greater part of the carapace, of which only the anterior portion is missing, and, following the carapace, a thin strip representing the first tergal plate of the opisthosoma. Behind the latter there lie, displaced to one side, the fourth, fifth, sixth, and seventh terga of the opisthosoma, which resemble in a general way the corresponding plates of Dr. Hind's specimen (No. 2). The carapace exhibits traces of the median ocular tubercle in front of its middle, but some distance from its anterior edge. The chelæ are slender, and recall those of some existing members of the Buthidæ, the "manus" being narrow, although wider than the brachium; the digits are long and slender, and apparently in contact throughout their length, the movable digit being a little more than twice the length of the back of the hand.

Approximate measurements in mm.—Width of carapace 3·5, of opisthosoma 4; length of humerus + brachium of chela 6, of manus + digits 5.

(2) Specimen in Dr. Wheelton Hind's Collection, showing the dorsal surface of the posterior part of the carapace, seven tergal plates and the first and second

caudal segments of the opisthosoma; also fragments of some of the anterior legs and apparently the maxillary processes of those of the first pair, where the anterior part of the carapace is missing. Of the fourth leg the trochanter, femur, patella, and part of the tibia are well exhibited. No trace of eyes is discernible. The sculpturing of the carapace, terga, and caudal segments is obscured, but the terga of the opisthosoma show clearly the anterior smooth elevated area which is normally overlapped in living Scorpions by the posterior border of the plate in front.

Approximate measurements in mm.—Length of abdominal terga of the opisthosoma 9·5, first tergum 1, third 1·5, fifth 2; width of opisthosoma 5; length of first and second caudal segments 4; femur of fourth leg 4, patella 3.

(3) Specimen in Mr. Egginton's Collection, showing, so far as the trunk is concerned, nearly the same features as Dr. Hind's example, the abdominal terga and two caudal segments of the opisthosoma being preserved. The anterior portion of the carapace is too much obliterated for description, but the ocular tubercle, in advance of the middle of this plate, is well shown with its two eyes. Fragments of appendages are shown on each side of the anterior half of the body, the femur of the left chela with an anterior granular crest, such as is present in most recent Scorpions, being preserved.

Approximate measurements in mm.—Total length from anterior end of carapace to posterior end of abdominal portion of opisthosoma 12, the carapace about 3 5, the rest 8·5; width of opisthosoma 5; distance of eyes from posterior edge of carapace 2; length of first caudal segment about 1, width nearly 2.

(4) Specimen in Mr. Egginton's Collection without tail and with the rest of the opisthosoma curved upwards as in the act of stinging. The chief interest of this specimen lies in the fact that the cheliceræ are preserved, showing obscurely the normal forcipate character of these appendages. Fragments of the appendages are obscurely indicated. Length of carapace about 3 mm.

(5) A very small, probably young specimen in Mr. Egginton's Collection, showing the dorsal view of carapace, of the anterior seven terga of the opisthosoma, and of the base of the tail. Total length (excluding base of tail) about 5 mm.; length of seven segments of opisthosoma 3·5 mm.; width 2 mm.

(6) Specimen in the British Museum, No. I. 1555 (Pl. I, fig. 2), from Coseley (Henry Johnson Collection). This example is of peculiar interest, since it shows portions of the sternal surface of the prosoma. The sternum is pentagonal, with its posterior border somewhat deeply excised; a little behind the excision lies a subtriangular genital operculum, and behind this there is a small sclerite representing the sternal plate of the pectines. Against the sides of the sternum on one side abut the coxæ of the legs of the third and fourth pairs as in existing Scorpions; and in front of it may be traced faint indications of the coxæ, with their maxillary processes, of the first and second pairs of legs; the maxillary

processes of those of the second pair appear to be exceptionally narrow. Seven terga of the opisthosoma are shown. These are very broad as compared with their length; but this may be due to flattening. At all events I do not propose to attach systematic weight to the character and separate this specimen specifically or generically from the others here described on the strength of this difference on the evidence of one specimen. Length of trunk (without tail) about 14 mm.; of seven segments of opisthosoma 9·5 mm.; width of opisthosoma about 6 mm.

The following fossils of doubtful generic position have also been referred to the Scorpiones.

(1) Segment of a tail from the Coal Measures of Carluke, Scotland (H. Woodward, Quart. Journ. Geol. Soc., vol. xxxii, pl. viii, fig. 5).

(2) Portion of a carapace referred by Peach to *Eoscorpius* sp. (Trans. Roy. Soc. Edinb., vol. xxx, pp. 404—405, pl. xxii, figs. 11 to 11*a*, 1883). The upper side of the carapace is swollen laterally, the swollen portions being separated by a median longitudinal groove, and each divided by lateral grooves into three portions. In front of the median groove lies the median ocular tubercle; lateral eyes are also described. According to Peach this carapace is intermediate between that of the species he described as *Eoscorpius tuberculatus* and *E. inflatus*.

(3) A carapace described by Peach as belonging to a species named *Eoscorpius inflatus* (Trans. Roy. Soc. Edinb., vol. xxx, pp. 405—406, pl. xxiii, figs. 12 to 12*d*, 1883). It is described as having the greater portion of its surface puffed up into three pairs of lobules separated by deep sulci, which emanate from a deep median longitudinal sulcus.

Peach himself suggests the possibility of this species belonging to the unclassified genus *Cyclus*. To a certain extent this author's descriptions of *E. inflatus* recall the characters of the carapace of some genera of Anthracomarti, such as *Eophrynus* and *Kreischeria*.

Order PEDIPALPI, Latreille.

Suborder UROPYGI.

Genus **GERALINURA**, Scudder.

1884. *Geralinura*, S. H. Scudder, Proc. Amer. Acad. Arts Sci., vol. xx, p. 19.
1890. *Geralinura*, S. H. Scudder, Mem. Bost. Soc. Nat. Hist., vol. iv, p. 454.
1904. *Prothelyphonus*, A. Fritsch, Palæoz. Arachn., p. 57.

Fritsch established the genus *Prothelyphonus* upon the species described by Kusta as *Thelyphonus bohemicus* and later as *Geralinura bohemica*. The alleged difference

between *Prothelyphonus* and *Geralinura* is the segmentation of the carapace in the latter and its entirety in the former; but since I cannot find any evidence from Scudder's figures of the type of *Geralinura*, namely *G. carbonaria*, that the carapace is segmented, I have placed *Prothelyphonus* as a synonym of *Geralinura*, reserving this name for the Carboniferous species of the Thelyphonidæ, not because they exhibit characters distinguishing them with certainty from existing genera, but because it is impossible to be sure that they belong to one or to more than one existing genus, and because the probabilities are in favour of their distinctness from all modern types.

No species of this group has hitherto been recorded from Great Britain. Several specimens, however, are contained in the collections at my disposal, although the material is, in my opinion, neither sufficiently abundant nor well preserved to admit of specific differences being with certainty established between the specimens. Provisionally, therefore, I refer them to one species.

The real interest of the specimens lies in the evidence they afford of the former existence of these Pedipalpi in Great Britain, and of their close agreement in structural characters with recent representatives of the suborder. Some of the Carboniferous specimens, that is to say, the two figured in this Monograph, seem to differ from modern types in having the three last segments of the opisthosoma less sharply marked off from the ninth segment and both wider and longer. But it is impossible to affirm this character of all extinct forms.

Geralinura britannica, sp. nov. Plate I, fig. 3; Plate II, fig. 3; Text-figure 9.

A species of small size with the dorsal surface covered with coriaceous granulation. Chelæ rather short and small, the five distal segments together rather shorter than the carapace. The three terminal segments of the opisthosoma long, nearly half the length of the rest of this region. Segments of the caudal flagellum about as wide as long.

Measurements in mm.—Total length from anterior end of carapace to end of the last segment about 17; length of carapace about 5, width 3·5; total length of opisthosoma (excluding flagellum) 11·5; width 4·5; length of segments two to nine, 8, ten to twelve (caudal portion) 3·5; length of visible portion of chela from base of femur 4·5.

Coseley, near Dudley.

Type in Mr. Walter Egginton's Collection, No. 51 (Pl. I, fig. 3).

This collection contains a second and less well-preserved specimen (No. 49) showing no features justifying its specific distinction from the type; and in Mr. Madeley's Collection there is an example from Coseley exhibiting the underside structurally in agreement, so far as can be seen, with recent forms. Its total

length is about 15·5 mm., the opisthosoma being 9·5 mm. and the prosoma 6 mm., the width of both regions being about 3 mm. There is a distinct spiniform process at the anterior extremity of the carapace as in certain recent forms, *e. g. Labochirus*.

In Dr. Moysey's Collection there is a specimen from the Shipley Claypit with the dorsal side exposed (Pl. II, fig. 3). The anterior portion of the carapace is broken away, showing vaguely the coalesced coxæ of the chelæ and the distal portion of the right chela. Behind the posterior border of the carapace there is a triangular plate which I regard as the posterior sternal plate of the prosoma, the exposure of which suggests that the overlying dorsal area was membranous; on each side of it may be seen the coxæ of the legs of the last pair. Nine terga of the opisthosoma are clearly discernible, but the three terminal segments of this

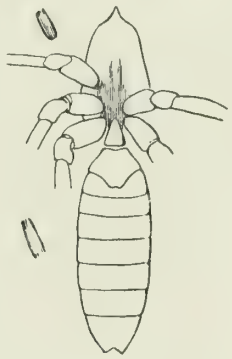


Fig. 9.—*Geralinura britannica*, sp. n.; restoration of ventral surface, three times nat. size.—Coal Measures; Coseley, near Dudley. W. Madeley Collection.

region are vaguely defined; they appear, however, to be comparatively large both in length and width; the post-anal flagellum is not preserved. Both the carapace and the terga and lateral membrane of the opisthosoma are granularly coriaceous.

Measurements in mm.—Total length about 20; length of opisthosoma 13, its length, excluding the last three segments, 10, its width 6; length of chela, excluding coxa, 7.

This specimen is a little larger than the type and has the chelæ decidedly longer. The difference in length, however, both of the body and the chela, may be attributable to age; and since the males of recent species very commonly have the chelæ much longer than they are in the females, it would be rash to attach specific importance to the difference observed, even if the type specimen were known to be fully adult.

Suborder AMBLYPYGI.

Genus **GRÆOPHONUS,** Scudder.

1890. *Græophonus*, S. H. Scudder, Mem. Bost. Soc. Nat. Hist., vol. iv, p. 453.

Although Scudder referred this genus to the same family of Pedipalpi as *Geralinura*, the two genera obviously belong respectively to the two suborders of the Pedipalpi known as Amblypygi and Uropygi.

Scudder only admitted one species of *Græophonus*, which he named *G. carbonarius*; but it appears to me to be very doubtful if the two specimens passing under that name can be referred even to the same genus. The type of *carbonarius* is an abdomen from Cape Breton and now in the Museum of the McGill College, Montreal. It was described as *Libellula carbonaria* under the belief that it belonged to a Neuropterous insect. It consists of twelve segments; but these are unlike the segments of any known Amblypygous Pedipalp, especially in the large size of the first and second plates. Moreover, the segments from the second to the seventh inclusive, are marked on each side *near the margin* by a circular impression. In the Amblypygi the tergal impressions are remote from the margin. On the other hand, the specimen from Mazon Creek, Illinois, upon which the genus *Græophonus* was quite clearly based, appears undoubtedly to be a Pedipalp of the suborder Amblypygi. Although Scudder identified this as *G. carbonarius*, it cannot, on the evidence, bear that specific name, as a comparison between the figures of this specimen (fig. 3, pl. xl, of the above-cited monograph) and the figures of *Libellula carbonaria* (pl. xl, figs. 2, 6) will make evident. In the Mazon Creek specimen the muscular tergal impressions are in agreement with those of a *Phrynus*; agreement may also be traced in many other particulars, such as the form of the carapace and the position of the ocular tubercle and the muscular grooves and pits. Scudder was, of course, mistaken in describing one of the chelæ as complete and nipper-like, its distal segments being obviously missing. It is in the structure of these appendages that *Græophonus* differs principally from recent genera of the group. Not only are they comparatively short and stout, especially with respect to the femoral segment, but, in addition, the axial rotation, which enables these limbs to fold up in a horizontal plane in recent forms, appears to be much less marked. They are, in fact, more porrect and fold in a nearly vertical plane, as was no doubt the case in primitive members of the Pedipalpi when the chelæ or palpi presented greater resemblance to the ambulatory limbs than is found in recent forms. This appears to me to be the chief character of morphological interest to be detected in *Græophonus*. One other distinctive feature may be mentioned. In all the specimens referred to this genus, where the carapace is well preserved, its anterior area, bearing the median ocular tubercle, is narrow and produced. This is shown

not only in the examples that I have seen, but also in Scudder's example from Mazon Creek, which I propose to call *Græophonus scudderi*.

Scudder describes this specimen as punctured. I do not doubt, however, that it was in reality finely granular.

It is somewhat singular that although only one undoubted specimen of *Græophonus* has been discovered in North America, and none have been recorded from Bohemia, the genus is represented in Britain by many specimens in the Carboniferous Beds of Staffordshire and South Wales.

Græophonus anglicus, sp. nov. Plate I, fig. 4.

Carapace approximately as long as wide, cordate, narrowed and produced anteriorly; the median ocular tubercle rounded, placed near the centre of the narrowed anterior portion, and defined behind by a crescentic groove; the area behind the tubercle rather flat; the median portion of the posterior part of the carapace a little elevated and marked with three impressions or muscular pits, one median in front and a pair, smaller and shallower, behind; from points on each side near these impressions radiate three grooves towards the margin. Opisthosoma elliptical, longer than wide, the terga marked with the normal muscular impressions. The distal end of the femur of the fourth leg, in its natural position, extending back beyond the extremity of the opisthosoma.

Tibia of palp or chela short, a little more than twice as long as wide, its length a little exceeding half the length or width of the carapace; its inner edge apparently armed with two spines; tarsus of chela apparently not less than half the length of the tibia, and also armed internally with two spines.

Approximate measurements in mm.—Total length 20; median length of carapace 7·5, lateral length 8·5; greatest width 8·5, width across front on a level with the ocular tubercle 2·5; length of opisthosoma 11 ?; length of segments four to nine 7·5; width of opisthosoma 8·5; length of tibia of chela 4, width 2.

Coseley, near Dudley.

The type, above described, is in the Collection of Mr. Walter Egginton (No. 1).

In addition to the type Mr. Egginton's Collection contains several examples of *Græophonus*, which I provisionally refer to this species. All are from Coseley.

The following points in them may be noted:

No. 40. Carapace approximately as in the type, the anterior oculiferous projection clearly shown. The terga of the opisthosoma are granular, and have a row of coarse granules along the posterior border. This region is narrower as compared with its length than in the type, the difference being perhaps sexual. Total length 14 mm., length of carapace 6, width 6·5; length of opisthosoma 8; femur of fourth leg about 8. Figured in Pl. I, fig. 4.

No. 2 shows more of the appendages than are seen in the type and No. 40, but

the anterior portion of the carapace is concealed; there is no evidence therefore that it projected forwards as in the other specimen. The greater portion of the chela is preserved, and the cheliceræ project forwards between their bases as a pair of slender rods. The coxæ of the posterior three pairs of legs are to be seen radiating from the narrow sternal area, and the legs of the second and third pairs are preserved nearly down to the ends of the tibiæ. The femur of the fourth leg is noticeably shorter than in No. 40. This difference may possibly be a question of age, the specimen now described being smaller than No. 40. In the chela the femoral segment appears to be spined internally. *Approximate measurements in mm.:* Total length 11; median length of carapace 3·5, width 4; length of opisthosoma 6·5, width 5; length of femur of second leg 4, of third 5, of fourth 5·5; coxa and trochanter of chela 2, femur 2, tibia 2·5.

No. 20: Larger than No. 2, but showing almost exactly the same features; the femur and tibia of the chela armed internally with a pair of spines. *Approximate measurements in mm.:* Total length 15·5; length of carapace 5, width about 6; length of opisthosoma 9, width 6·5; length of femur of second leg 7, of third 7·5, of fourth 9; length of femur of chela 3, its width 1·8; length of tibia of chela 4, its width 1·8.

In Mr. Henry Johnson's Collection from Coseley there is a specimen less well preserved than those described above and showing no points worthy of special comment. Its total length is about 13·5 mm., of which the carapace is 5 mm. and the opisthosoma 8·5 mm.; femur of third leg 6·5 mm.

In the Museum of the Geological Survey, Jermyn Street, there are a well-preserved opisthosoma, measuring 15 mm. long and 8 mm. wide, and a carapace measuring 4·5 mm. long and 6 mm. wide, which perhaps belong to the same species. They were found at the tip of an abandoned shaft (Glasbrook's) close to Cadoxton village, one and one-eighth miles north-east of Neath Station in S. Wales. There is no reason to suppose that these fragments belong to the same specimen. It may be noted that this carapace bears considerable resemblance to that of *G. scudderi*, but has the produced anterior region larger.

Order ARANEÆ, Sundevall.

Suborder MESOTHELÆ.

Genus **EOCTENIZA**, nov.

Generic Characters.—Carapace with its anterior portion somewhat sharply constricted to form a narrow, rounded, elevated, and convex cephalic area, defined from the large and broadly cordate posterior portion by a pair of shallow grooves,

which nearly meet in the middle line. This cephalic area bears the eyes, arranged in a transversely elongated, suboblong cluster, near its anterior border. The posterior area of the carapace is marked with three pairs of radiating grooves, those of the first pair being short and of the other pairs long; behind the posterior pair of these there is an angular median depression, the central fovea, from which passes a posterior pair of grooves. Opisthosoma oval, showing six distinct tergal plates.

Type Species.—Eocteniza silvicola, sp. nov.

In the Carboniferous genera and species of Araneæ with segmented opisthosoma, namely *Arthrolycosa antiqua*, Harger, *Scudderia carbonaria*, Kusta, ? genus *fortis*, Fritsch, ? genus *beecheri*, Fritsch, *Eolycosa lorenzi*, Kusta, *Protolycosa anthracophila*, Roemer, *Geralycosa fritschi*, Kusta, and *Rakovnicia antiqua*, Kusta, there appears to be no differentiated cephalic area such as is seen in *Eocteniza*. In *Palaranea borassifolia*, Fritsch, which its describer, in his last paper, re-named *Arthrolycosa? palaranea*, there is no evidence that the opisthosoma is segmented, and therefore no reason for assigning the fossil to the genus *Arthrolycosa*. The type of *Eolycosa lorenzi* shows only a side view of the animal; but in this genus it appears that the whole carapace is strongly elevated. It may be added that the species *antiqua*, *carbonaria*, *fortis*, *beecheri*, *lorenzi*, and *borassifolia*, which Fritsch refers to the one genus *Arthrolycosa*, represent at least six genera and possibly as many families if the drawings are to be trusted.

Eocteniza silvicola, sp. nov. Plate II, fig. 4.

Carapace 5 mm. long, 4 mm. wide; abdomen about 5 mm. long, 3·5 mm. wide.
Coseley, near Dudley.
Type and only known specimen in the Collection of Mr. Walter Egginton.

Genus **ARTHROLYCOSA**, Harger.

1874. *Arthrolycosa*, O. Harger, Amer. Journ. Sci. [3], vol. vii, p. 219.
1889. *Arthrolycosa*, C. E. Beecher, Amer. Journ. Sci. [3], vol. xxxviii, p. 219.

I refer with doubt to this genus a fossil (Text-fig. 10) in Dr. Wheelton Hind's Collection, which is of very great morphological interest, although its exact systematic position is indeterminable. That it belongs to the order Araneæ rather than to the Pedipalpi, I infer from the shape of the carapace and of the opisthosoma. The carapace, although imperfect, appears to be about as broad as long, with nearly straight anterior and posterior borders and evenly convex lateral borders. It is marked with radial impressions and a somewhat Λ-shaped median

impression just in front of the posterior border. Faint indications of the basal segments of the legs are traceable on one side, no trace of the coxæ or sternal area of the prosoma being observable. The opisthosoma is wide, with its lateral and posterior borders strongly rounded; it is markedly narrowed in front and is distinctly segmented on its dorsal area, the terga extending across the whole width of this region from side to side. Of the segmentation of the greater part of the ventral surface I can affirm nothing with certainty except as regards the posterior extremity, where two annuliform segments surround the last or anal segment. The latter, as I interpret the fossil, consists of a transversely subelliptical tergal plate and of a crescentic sternal plate.

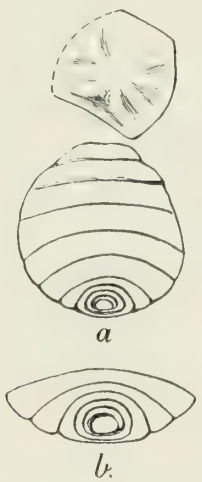


Fig. 10.—? *Arthrolycosa*, sp.—Coal Measures; Coseley, near Dudley. Wheelton Hind Collection. *a*, dorsal surface of carapace and of opisthosoma, the posterior segments of the latter showing through the overlying last tergal plate visible on the dorsal side, about four times nat. size; *b*, terminal segments of the opisthosoma, about six times nat. size.

Approximate length and width of carapace 4 mm.; length of opisthosoma 6 mm.; with 5·5 mm. or possibly less, if this region is expanded by crushing.

Coseley, near Dudley.

The morphological interest of this specimen lies principally in the structure of the posterior segments of the opisthosoma, which are unlike those of all recent Araneæ in being annuliform and firmly chitinised. In this character the fossil shows a nearer approach to the Pedipalpi, serving in a measure to bridge the interval between these two orders, which are admittedly related to one another. No trace of spinning appendages is to be seen. If they had been close to the anus, as in all recent Spiders except *Liphistius*, indication of this would probably have been preserved. Hence it may be supposed that they were situated somewhere near the middle of the ventral surface as in the last-named genus.

Suborder OPISTHOTHELÆ.

Genus **ARCHÆOMETA**, nov.

Generic Characters.—Resembling in general form such recent genera as *Nephila* and *Tetragnatha*, and possibly, like these, belonging to the family Argyopidæ. Carapace apparently cordate, narrowed in front. Legs very long and slender, probably 2, 4, 3, 1 in order of length judging by the length of the femora, though possibly those of the first pair exceeded those of the third by reason of the probably greater length of their terminal segments. The legs of the first and second pairs in most recent Araneæ (Spiders) are subequal in length, but in this Carboniferous genus those of the second pair greatly exceed those of the first. Femur of third longer than of first, femur of fourth a little longer than that of second. Abdomen long, apparently rather longer than femur of fourth leg, but its exact length a little doubtful owing

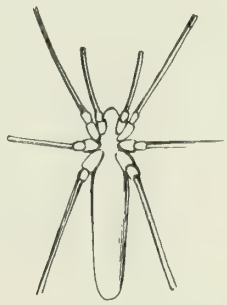


Fig. 11.—*Archæometa nephilina*, gen. et sp. n.; restoration of the ventral surface, showing the legs as far as the distal end of the femora and the probable form of the opisthosoma, about two and a half times nat. size.—Coal Measures; Coseley, near Dudley. W. Egginton Collection.

to the want of definition of its posterior end; subcylindrical in shape, a little narrowed posteriorly, ovally convex apparently anteriorly and rather more than three times as long as wide.

Type Species.—*Archæometa nephilina*, sp. nov.

The discovery of this Spider is of very great interest, because it puts beyond reasonable doubt the existence in the Carboniferous epoch of the Arachnomorphæ, which were previously not known to occur earlier than the Oligocene. It is, perhaps, necessary, however, to qualify this statement in connection with the genus and species described by Fritsch as *Pyritaranea tubifera*, which has the appearance of an Arachnomorphous form. But it is impossible to say much about this genus because the segmentation of the appendages, as represented by this author, is quite unlike that of any known Arachnid, living or extinct. Assuming that *Pyritaranea* was one of the Arachnomorphæ, as Fritsch suggests by his reference to the Clubionidæ in connection with it, *Archæometa* certainly differs from that genus in the greater length of its legs. In *Pyritaranea*, for example, an entire leg of the fourth pair only slightly exceeds the abdomen in length, and the

other legs are correspondingly short. The palpi, on the contrary, which are not shown in the specimen of *Archæometa*, are of most unusual length.

Archæometa nephilina, sp. nov. Text-figure 11.

Total length about 10 mm.; carapace about 3 mm. long, 2 mm. wide; abdomen about 7 mm. long, 2 mm. wide; femur, trochanter, and part of coxa of first leg 4 mm., of second leg 7·5 mm., of third leg about 5 mm., of fourth leg 8 mm.

Coseley, near Dudley.

Type and only known specimen in the Collection of Mr. Walter Egginton.

Order RICINULEI, Thorell.

Carapace or dorsal shield of the prosoma unsegmented, but with a movable plate, the cucullus, jointed to its anterior border and overhanging the jaws in front. Prosoma and opisthosoma united by a jointed waist, often marked by a lateral constriction. The opisthosoma either not visibly segmented or composed in the main of three very large segments, the last carrying a small jointed tail-like process, which is not always exposed; sometimes a shorter segment is visible in front of the first of the three large segments.

It is needless to give a complete diagnosis of this order, derived from the existing genera *Cryptostemma* and *Cryptocellus*. For this, reference may be made to Hansen's and Sörensen's monograph of 1904. The characters briefly enumerated above are taken from the known Carboniferous genera, and are sufficient to distinguish the Ricinulei from the other orders discussed in this Monograph.

Family Cryptostemmidæ, Westwood.

1874. *Cryptostemmidæ*, J. O. Westwood, Thes. Ent. Oxon., p. 210.
1884. *Poliocheridæ*, S. H. Scudder, Proc. Amer. Acad. Arts Sci., vol. xx, p. 16.
1890. *Poliocheridæ*, S. H. Scudder, Mem. Bost. Soc. Nat. Hist., vol. iv, p. 444.
1892. *Cryptostemmidæ*, T. Thorell, Bih. Svensk. Vet.-Akad., vol. xvii, 4, No. 9, p. 9.
1904. *Cryptostemmatoidæ*, H. J. Hansen and W. Sörensen, On Two Orders of Arachnida, p. 144.

I provisionally refer the Carboniferous genera of this order to the family Cryptostemmidæ, which has the characters of the order.

The two genera here admitted may be distinguished as follows:

a. Opisthosoma elongate, narrowed posteriorly, not consisting mainly of three large segments; cucullus transversely suboblong, markedly wider than long. *Curculioides*.

a'. Opisthosoma shorter, widely rounded posteriorly, composed mainly of three large segments; cucullus large, nearly as long as its basal width. . . *Poliochera*.

Genus **CURCULIOIDES**, Buckland.

1837. *Curculioides*, W. Buckland, Bridgewater Treatise (ed. 2), vol. ii, p. 76 (in part, *C. ansticii*).
1902. *Curculioides*, R. I. Pocock, Geol. Mag. [4], vol. ix, p. 439.
1890. *Geratarbus*, S. H. Scudder, Mem. Bost. Soc. Nat. Hist., vol. iv, p. 447 (in part, *G. scabrum*).
1890. ? *Kustarachne*, S. H. Scudder, Mem. Bost. Soc. Nat. Hist., vol. iv, p. 450.
1903. *Kustarachne*, A. L. Melander, Journ. Geol. (Chicago), vol. xi, p. 181.

The genus *Curculioides* was based by Buckland on two fossils in ironstone nodules from Coalbrook Dale, which this author regarded and described as Coleopterous insects. One of these was named *C. ansticii*, the other *C. prestvicii*. The latter was subsequently made the type of *Eophrynus* by Dr. Henry Woodward, who thus fixed *C. ansticii* as the type of *Curculioides*. In 1884 Scudder suggested that *C. ansticii* was an Arachnid related to *Architarbus*. I, on the contrary, suggested that it was allied to *Cryptostemma*, judging solely from the figure of it published by Buckland. The correctness of this surmise and the reasons given in support of it have been confirmed by specimens in Mr. Egginton's and Mr. Madeley's Collections.

That the Arachnid described by Scudder as *Geratarbus scabrum* is closely related to those that I refer to *Curculioides* is, I think, indisputable; but it is equally indisputable, in my opinion, that *G. scabrum* belongs to a different order of Arachnida from *G. lacoei*, which I have fixed as the type species of *Geratarbus* (Geol. Mag. [5], vol. vii, p. 511, 1910). About *Kustarachne* there is more room for doubt on account of Scudder's statement that the opisthosoma consists of nine segments, including the short two-jointed "protuberant pygidium." Although none of the specimens I have seen shows distinct signs of abdominal segments, the one in Mr. Madeley's Collection possesses what might be called a "protuberant pygidium," and this process is also well exhibited in Buckland's original figure. Nevertheless, it would have been difficult to justify the suggestion that *Kustarachne*, based upon *K. tenuipes*, belongs here, were it not that the species described by Melander as *K. sulcata* seems to be unmistakably akin to the examples in Mr. Egginton's Collection, which show the ventral side. Melander described *K. sulcata* as deeply punctured and as being provided with a triangular sessile pygidium of two, possibly three, segments. Apart from this last character the abdomen seems to show no segments. It is possible, of course, that *Kustarachne tenuipes* and *K. sulcata* differ generically. Nevertheless, the measurements of the two type specimens agree suspiciously closely, and both came from Mazon Creek, Illinois. I suspect that one shows the dorsal, and the other the ventral view of specimens belonging to the same species.

Curculioides ansticii, Buckland. Plate II, fig. 7; Text-figures 12, 13.

1837. *Curculioides ansticii*, W. Buckland, Bridgewater Treatise (ed. 2), vol. ii, p. 76, pl. 46″, fig. 1.

The exposed surface of both dorsal and ventral sides is closely covered with small punctures marking the hollows of granules. A specimen in Mr. Egginton's Collection (Pl. II, fig. 7), showing the dorsal surface from the ventral side and the ventral surface from the dorsal side on the two halves of a split nodule, has the carapace flattish and only a little vaulted, and apparently about as wide as long, though its lateral margins are not clearly defined. The posterior end of the abdomen is markedly narrowed. Portions of the legs are well shown, especially on the right side. The first and third are preserved as far as the end of the patella,

Fig. 12.—*Curculioides ansticii*, Buckland; suggested restoration of ventral surface of specimen No. 17, four times nat. size.—Coal Measures; Coseley, near Dudley. W. Egginton Collection.

Fig. 13.—*Curculioides ansticii*, Buckland; dorsal surface, three times nat. size.—Coal Measures; Coseley, near Dudley. W. Madeley Collection.

of the second and fourth as far as the end of the femur. The first leg is the thinnest and the second the longest of the series, the femur of the second being about as long as the femur + patella of the third. *Approximate measurements in mm.:* Total length about 11, length (without cucullus) and width of carapace 4, length of abdomen 6·5, length of trochanter and femur of first leg 4, of second 6, of third 5, of fourth 6·5, of the femora alone in the order named 3, 5, 3, 3·5.

Another specimen (No. 17) in Mr. Egginton's Collection shows no structural features not exhibited in the first and is much less perfectly preserved. The abdomen appears to be more evenly oval and less narrowed posteriorly. The entire animal, in fact, seems to resemble *C. scaber* of Scudder in shape. *Approximate measurements in mm.:* Total length 12, length of carapace 4, width of carapace 4, length of abdomen 8, width of abdomen 5.

In Mr. Madeley's Collection there is a fairly well-preserved example showing the cucullus apparently entire. It has convex lateral margins and rounded angles;

its anterior and posterior borders are straight and parallel, and the plate does not expand towards its anterior border, as in existing genera, so that it may be described as transversely oblong. The carapace is a little wider than long, with the lateral borders convex, the widest point lying a little in front of the middle; its surface is moderately vaulted, its anterior portion being distinctly but evenly curved downwards towards the edge to which the cucullus is hinged. A distinct but shallow constriction marks the junction of the carapace and abdomen. The latter is elongate and oval, rather wider than the carapace; behind the widest point in front, the sides are slightly convex and converge gradually towards the posterior extremity, which shows indication of a median lobate excrescence. Portions only of some of the legs are preserved. *Approximate measurements in mm.:* Total length 12·5; length of carapace 4·5, width about 5; length of cucullus 1, width 2·5; length of abdomen 8, width about 5.

Thus these three specimens from Coseley, near Dudley, agree tolerably closely in dimensions. The type of *C. scaber*, Scudder, on the contrary, was larger, the total length being 15 mm., the length and width of the carapace 5·25 mm., the length of the abdomen 9·75 mm., and the width 6·25 mm. These measurements may be instructively compared with those of *Kustarachne sulcata*, Melander, from the same locality, namely Mazon Creek, Illinois, the total length being 15 mm. and the abdomen, without the "pygidium," 9 mm., with a width of 7 mm. Thus there is the same close agreement between the American specimens as between the English examples.

Genus **POLIOCHERA**, Scudder.

1838. *? Cryptostemma*, Guérin-Méneville, Rev. Zool., p. 10.
1884. *Poliochera*, S. H. Scudder, Proc. Amer. Acad. Arts Sci., vol. xx, p. 16.
1890. *Poliochera*, S. H. Scudder, Mem. Bost. Soc. Nat. Hist., vol. iv, p. 444.

Characters as above (p. 37).

Poliochera alticeps, sp. nov. Plate II, fig. 6; Text-figure 14.

Carapace elevated, convex from before backwards; the elevated area marked with a median groove ending behind in an impression, and an impression, probably muscular, far out on each side of this, a posterior curved groove passing on each side into a deeper impression defining the elevated area behind; the median length of the carapace about equal to its posterior width and as long as the anterior two large terga of the opisthosoma.

Opisthosoma wider than the carapace, its width less than its length; the three large segments subequal in length; each marked apparently with two

pairs of impressions, the anterior pair of the first small and widely separated, the posterior pair larger and closer together; those of the other terga equidistant from the middle line and in approximately the same straight line as the posterior pair of the first large tergal plate.

Measurements in mm.—Total length, exclusive of cucullus and caudal elongation, 5·5; length of carapace, excluding cucullus 2, width about 2·5; length of opisthosoma 3·5, width 2·8; length of first leg about 4·5, of third leg about 4.

Coseley, near Dudley.

Type and only known specimen in the Collection of Mr. Walter Egginton (No. 6).

This specimen, in a split nodule of clay ironstone, shows very clearly the dorsal surface with apparently the entire cucullus, portions of four pairs of ambulatory appendages and a short two-jointed caudal process.

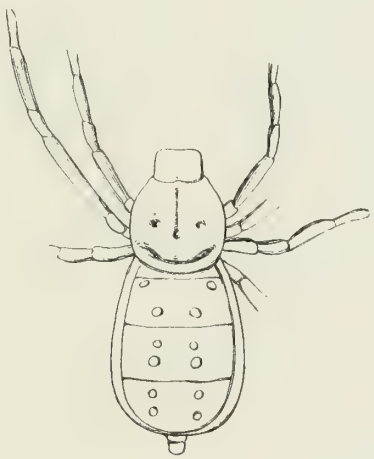


Fig. 14.—*Poliochera alticeps*, sp. n.; dorsal surface, showing the muscular impressions on the carapace and on the terga of the opisthosoma, six times nat. size.—Coal Measures; Coseley, near Dudley. W. Egginton Collection.

Although the type species of the genus *Poliochera*, namely *P. punctulata*, Scudder, shows no cucullus and is described as having the carapace flat, I think it probable that *P. alticeps* belongs to the same genus. Apart from the convexity of the carapace *P. alticeps* may be distinguished by its much smaller size, *P. punctulata* measuring 15 mm. in total length, of which the carapace is 6.

Order HAPTOPODA, nov.

No constriction between the prosoma and the opisthosoma, these regions apparently movably jointed together; the posterior end of the prosoma as wide as the anterior end of the opisthosoma. Carapace of prosoma approximately as wide as long, without trace of transverse grooves indicating segmentation. Opisthosoma longer than wide, narrowed posteriorly, rounded at the extremity, exhibiting in

one case ten terga on the dorsal side, and always a small anal operculum beneath the last, but on the ventral side. Thus eleven segments are traceable in the opisthosoma. The number of sterna is doubtful; but there appear to be at least nine, excluding the area between the coxæ of the last pair of legs, the first sternal plate being large with a widely convex posterior edge and the last small and encircling the sides and lower edge of the anal operculum. Mandibles or cheliceræ not fully known, but their basal segment elongate and porrect. Palpi short and pediform, consisting of six segments, the basal segment (maxilla) the largest, not concealed from below, and slightly divergent from its fellow of the opposite side. Legs of the first pair long, somewhat like those of the Thelyphonidæ, the terminal

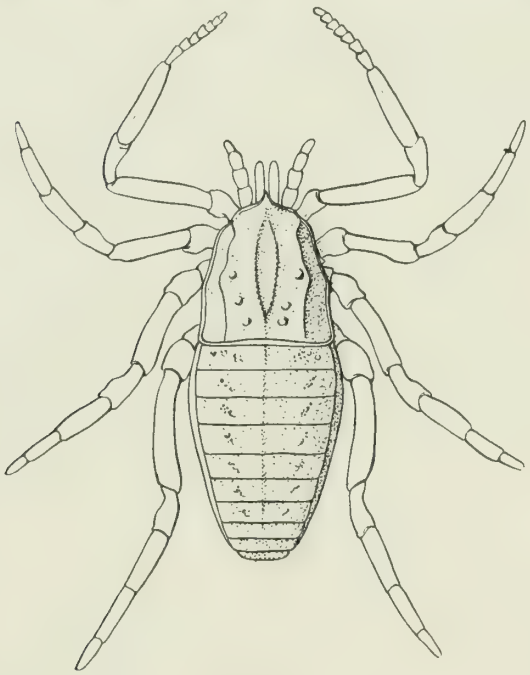


FIG. 15.—*Plesiosiro madeleyi*, gen. et sp. n.; dorsal surface with appendages restored from several specimens, four times nat. size.—Coal Measures; Coseley, near Dudley.

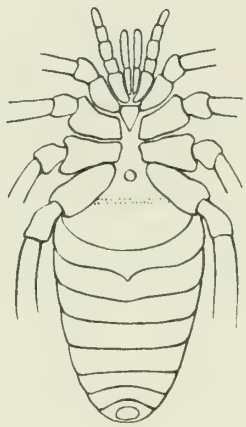


FIG. 16.—Suggested restoration of ventral surface of the same.

segments (protarsus and tarsus) converted into a seven-jointed tactile organ, apparently without a claw; the rest of the segments normal in number and structure. The remaining legs ambulatory, similar in form and in segmentation, each consisting of the normal seven segments characteristic of the Arachnida, the patella being short and the terminal segment (tarsus) undivided. Claws unknown. The basal segments large, those of the fourth leg the largest, separated in the middle line by an elongated sternal area which seems to expand behind between the coxæ of the fourth pair. Sternal plates of prosoma unknown, except for a small triangular anterior sternal plate lying immediately behind the basal segments of the palpi, and between those of the legs of the first pair and partially also between those of the second pair. Position of generative orifice unknown.

I have established this new Order, named in allusion to the tactile nature of the legs of the first pair, for a genus of Carboniferous Arachnida which cannot be fitted into any other Order of extinct or existing forms. In some respects it coincides with the definition of the Opiliones, notably in the total absence of constriction between the prosoma and opisthosoma, and in the number and nature of the tergal plates of the opisthosoma, and could hardly, indeed, be excluded from that Order by the structure of the appendages as seen from the dorsal side, although differing from all its known members in the *Thelyphonus*-like modification for tactile purposes of the legs of the first pair. The structure of the anal segment is also like that of some Opiliones, *e. g. Cyphophthalmus*, but it is also like that of the Anthracomarti. The arrangement, however, of the sternal plates of the opisthosoma and the position of the basal segments (coxæ) of the prosoma with regard to the sternal area of that region, so far as I can decipher them, are very different from what may be seen in the Opiliones. They may, indeed, be described as more in conformity with the normal and primitive than is exhibited in that Order, which in these particulars is the most specialised of all Arachnida, with the exception of the Acari.

Family Plesiosironidæ, nov.

Genus **PLESIOSIRO**, nov.

Generic Characters.—Carapace high, narrowed in front, its anterior border produced into a median beak-like spiniform process; marked on each side by a longitudinal crest extending from a point close to its antero-lateral angle to its posterior border; the area external to these crests sloped abruptly down to the lateral edge; the area between the crests flattish and marked with a pair of lightly-curved crests, which arise at the base of the spiniform process, diverge, then converge, and meet a little in front of the posterior border; posterior border straight. Opisthosoma narrowed posteriorly, the terga much wider than long, with straight posterior border, the last only being convex posteriorly. The sternal plate of the last, lying just in front of the transversely oval or subcircular anal operculum, strongly angled, the preceding two sterna progressively less strongly angled. Opisthosoma bordered laterally by an unsegmented ridge representing probably the pleural integument of this region.

Palpi with second segment (trochanter) short; third, fourth, and fifth segments longer and subequal in length; the sixth short and tapering. Legs longish, the femora and tibiæ the longest segments; tibia of first compressed; basal segment of terminal tactile portion of the limb much longer than the rest individually.

Type Species.—*Plesiosiro madeleyi*, sp. nov.

Plesiosiro madeleyi, sp. nov. Plate II, fig. 5; Text-figures 15, 16.

Integument finely granular. Carapace with its admedian crests finely beaded; the lateral crests apparently smoother; three tubercles forming an oblique line in the posterior half of the area on each side between the crests; the posterior width of the carapace a little less than its median length, the latter a little greater than the length of the anterior five terga of the opisthosoma. Opisthosoma longer than wide, its width about equal to the length of the anterior six terga; a narrow median granular crest on the anterior seven terga, and a few large granules forming an irregular, oblique, abbreviated crest on each side. The eighth tergal plate considerably shorter than the seventh; the ninth and tenth much shorter than the eighth.

First leg, excluding the coxa, about as long as the body; its femur about as long as the first four terga of the opisthosoma; and a little longer than the tibia; the tibia about twice as long as the patella; the basal segment (protarsus) of the terminal tactile portion longer than the other segments individually. Fourth leg with trochanter and femur about equal in length to the carapace. The four distal segments of the palpi about half the length of the carapace.

Measurements in mm. (of type).—Total length 11·5; length and width of carapace 5; length of opisthosoma nearly 7, its width 5, length of first leg about 11.

Coseley, near Dudley.

Type in the Collection of the late Mr. William Madeley. This specimen shows the basal segments of the mandibles, the two palpi, one complete leg of the first pair, the femur, patella, and half the tibia of the third leg, the femur and patella of the fourth, and the femur of the second; the shape of the carapace and the tergal plates of the opisthosoma. Also the posterior sterna of the opisthosoma; and the hollow spaces of the basal segments of the legs of the first pair.

Other specimens in Mr. Madeley's, Dr. Hind's, Mr. Priest's, and Mr. Egginton's Collections show additional features which have made it possible to restore the dorsal surface tolerably completely. Details of the ventral surface are in no instance well preserved, the sterna and the genital area of the opisthosoma being in every case obscurely indicated. A specimen in Mr. Egginton's Collection (No. 4) is noteworthy for being the only one to show ten distinct tergal plates on the dorsal side of the opisthosoma, the ninth and tenth in this specimen appearing as a single plate in the others, where the posterior end of the opisthosoma is preserved (Pl. II, fig. 5).

Order PHALANGIOTARBI, Haase.

1890. *Opiliones*, sub-order *Phalangiotarbi*, E. Haase, Zeitschr. deutsch. geol. Ges., vol. xlii, p. 650.
1910. *Phalangiotarbi*, R. I. Pocock, Geol. Mag. [5], vol. vii, pp. 508—512.

Carapace of prosoma unsegmented, bearing a single pair of median eyes near its anterior border. No constriction between the prosoma and opisthosoma, but the two regions apparently movably jointed together. Terga of the opisthosoma eight or nine in number and referable to two categories; the anterior five or six quite short and apparently movably jointed, the posterior three long and apparently fused, though the sutures between them persist. Sterna of the opisthosoma apparently only seven in number, the posterior three corresponding with the posterior three terga and the anterior four with the anterior six terga; the first sternal plate triangular and wedged between the coxæ of the last pair of appendages of the prosoma. The genital orifice either just in front of or just behind this plate. The anal orifice small, subapical, and perhaps closed by an operculum representing a tenth segment. Legs, where known, alike in structure and consisting of seven segments, of which the fourth or patella is subequal in length to the third (femur) or fifth (tibia). Palpi, where known, very short, slender, and pediform.

This Order is wholly extinct and is only known from the Coal Measures of Europe and North America.

Although this group has some structural points in common with the recent Opiliones, such as the single pair of eyes, the absence of constriction between the prosoma and the opisthosoma, the presence of probably ten segments in the opisthosoma and the simple, not chelate, palpi, I think it advisable, in the present state of our knowledge, to keep the two apart, the segmentation of the opisthosoma in the Phalangiotarbi being quite unlike that of the Opiliones.

Family Phalangiotarbidæ.

Phalangiotarbidæ, Haase and Pocock (references as above under Phalangiotarbi).

Sternal area of prosoma relatively large and longitudinally elliptical, considerably longer than wide. The coxæ of all the post-oral appendages radiating round it, with their distal margins overlapped by the edge of the carapace. Coxæ of the palpi narrow, and in contact in the middle line in front; coxæ of legs of first pair lying on each side of them and diverging obliquely forwards and outwards, not in contact with each other; those of the fourth pair diverging obliquely backwards and widely separated at their proximal ends and followed by a pair of coxa-like

sclerites separated by a narrow median suboblong area. Opisthosoma bearing eight tergal plates, of which the anterior five are short and nearly straight or slightly recurved, indicating that the posterior border of the carapace was also straight from side to side; these are followed by the three normal large plates.

With the exception of the three plates lying behind the sternum of the prosoma and the coxæ of the legs of the fourth pair, the significance of which is obscure, the morphology of this Arachnid, judging from the figure, seems to be clear. Judging from the size of the sternum of the prosoma and the wide separation of the coxæ of the legs of the first and fourth pairs, *Phalangiotarbus* is the least specialised member of the Phalangiotarbi.

Genus **PHALANGIOTARBUS,** Haase.

1872. *Architarbus*, H. Woodward, Geol. Mag., vol. ix, p. 385, pl. ix, fig. 1 *a*—*b* (*nec* Scudder).
1890. *Phalangiotarbus*, E. Haase, Zeitschr. deutsch. geol. Ges., vol. xlii, pp. 638 and 650, pl. xxx, fig. 3.
1910. *Phalangiotarbus*, R. I. Pocock, Geol. Mag. [5], vol. vii, pp. 510 and 512.

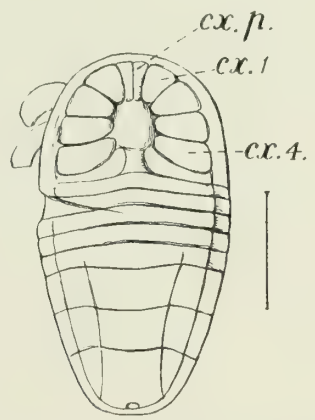


Fig. 17.—*Phalangiotarbus subovalis* (Woodward); ventral surface of the prosoma and dorsal surface of the opisthosoma exposed, three times nat. size.—Coal Measures; Lancashire. *cx. p.*, coxa of palp; *cx. 1*, coxa of first leg; *cx. 4*, coxa of fourth leg. After H. Woodward, Geol. Mag., vol. ix, pl. ix, fig. 1.

Characters as above.

Type Species.—*Architarbus subovalis*, H. Woodward.

Phalangiotarbus subovalis (H. Woodward). Text-figure 17.

1872. *Architarbus subovalis*, H. Woodward, Geol. Mag., vol. ix, p. 385, pl. ix, fig. 1 *a*—*b*.
1890. *Phalangiotarbus subovalis*, E. Haase, Zeitschr. deutsch. geol. Ges., vol. xlii, pp. 638 and 650, pl. xxx, fig. 3.
1904. *Architarbus suboralis*, A. Fritsch, Palæoz. Arachn., p. 35, fig. 39.
1910. *Phalangiotarbus subovalis*, R. I. Pocock, Geol. Mag. [5], vol. vii, p. 510.

The type and only known specimen of this species, which is known to me solely from the figure and description, is imbedded in an ironstone nodule from the Coal Measures of Lancashire.

Family Architarbidæ, Karsch.

Sternal area of prosoma small, and either subcircular or more usually narrow and elongate, the proximal ends of the coxæ being close together; the distal ends of the coxæ not, or hardly, overlapped by the edge of the carapace. Coxæ of palpi usually, at all events, entirely concealed from below by those of the legs of the first pair, which meet throughout their length in the middle line; only in *Geratarbus* do they appear to be in contact at their proximal ends, and diverge to a slight extent outwards, leaving a narrow space between. Coxæ of legs of fourth pair also meeting, or almost meeting proximally behind the posterior end of the sternal area. Opisthosoma with eight or nine tergal plates.

This family, in the sense in which I have recently defined it (Geol. Mag. [5], vol. vii, p. 512), contains several genera, of which only one, *Geraphrynus*, is known to be British, the others, namely, *Architarbus*, Scudder, *Geratarbus*, Scudder, and *Opiliotarbus*, Pocock, having been recorded from North America.

Genus **GERAPHRYNUS**, Scudder.

1884. *Geraphrynus*, S. H. Scudder, Proc. Amer. Acad. Arts Sci., vol. xx, p. 16.
1890. *Geraphrynus*, S. H. Scudder, Mem. Bost. Soc. Nat. Hist., vol. iv, p. 445.
1904. *Geraphrynus*, A. Fritsch, Palæoz. Arachn., p. 33 (in part).
1910. *Geraphrynus*, R. I. Pocock, Geol. Mag. [5], vol. vii, pp. 510, 512.

Generic Characters.—Body typically wide, its width across the anterior half of the opisthosoma nearly half the total length. Carapace usually angular in front, with its anterior lateral margins convex and gradually diverging to the posterior lateral angles, where the plate is widest; its posterior border either evenly convex or produced posteriorly in the middle. A pair of median eyes near the anterior extremity. Opisthosoma with nine tergal plates, the first two or more following the curvature of the posterior border of the carapace; the sixth segment much shorter than the seventh, and generally a little, sometimes markedly, longer than the fifth. A sulcus commonly traceable on each side of the terga, extending from a point not far from the postero-lateral angles of the carapace to the convex posterior border of the ninth plate, terminating one on each side of the anal orifice, and dividing the terga into three areas, a median and two lateral. The anal orifice subapical, and probably closed by a small opercular plate representing

the tergum of the tenth segment. Ventral surface of opisthosoma typically with seven sternal plates; the last three large and corresponding to the last three terga; the anterior four corresponding to the anterior six terga. The first and second sterna small and visible in the intercoxal space of the legs of the last pair, the first being triangular. Apparently a small orifice, the genital orifice, situated at the anterior extremity of the first and behind the sternal area of the prosoma.

Sternal area of prosoma narrow, much longer than wide, and consisting of five small plates, one pair between the coxæ of the legs of the third and fourth pairs, a second pair between those of the second legs and a small unpaired plate just behind the contiguous coxæ of the legs of the first pair.

Coxæ of the four pairs of legs large, triangular, and wedge-shaped, occupying the whole ventral area of the prosoma, with the exception of the narrow sternal region; each leg consisting of seven segments, including the coxa; the second

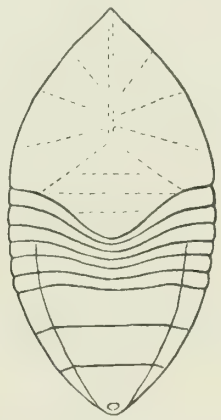


Fig. 18.—*Geraphrynus carbonarius*, Scudder; diagrammatic restoration of the dorsal surface of the type specimen, adapted from Scudder's figure (Proc. Boston Soc. Nat. Hist., vol. iv, pl. x, fig. 10), the dotted lines representing the coxal and sternal sclerites underlying the carapace, nearly three times nat. size. —Coal Measures; Mazon Creek, Illinois, U.S.A.

segment (trochanter) stout but short; the remaining segments thinner and longer, and not very unequal in length, with the exception of the seventh or tarsus, which is quite short, the fourth segment or patella being long, and not short as in the Opiliones. Palpi very short, probably six-jointed, their basal segments concealed from below by the united coxæ of the legs of the first pair.

Type Species.—Geraphrynus carbonarius, Scudder.

This generic diagnosis is based for the most part upon the British material of this genus that I have seen, checked by comparison with Scudder's figure of the type specimen of the typical species of the genus, *G. carbonarius*. Judging from this figure, *G. carbonarius* differs from all those described in this paper in the large size of the carapace as compared with the opisthosoma, the median length of the former exceeding the median length of the latter.

It is impossible to say with certainty how many species are represented by the

material from Dudley that I have seen. The following six, which may be determined by the subjoined key, appear at least to be distinguishable forms:

a. Carapace as wide as long or wider; length of the anterior four sternal plates of the opisthosoma much less than that of the posterior three.
  b. The posterior border of the carapace markedly sinuous, its lateral portions being slightly concave and its median portion convexly produced in the middle line.
    c. Opisthosoma longer and narrower in its posterior portion, the width of its penultimate segment about equal to the median length of the carapace; the posterior border of the seventh and eighth terga distinctly angled *angulatus*.
    c'. Opisthosoma shorter and wider in its posterior portion; the width of the penultimate segment considerably exceeding the median length of the carapace . . . . . *hindi*.
  b'. The posterior border of the carapace not markedly sinuous, either evenly convex or with its lateral portion nearly straight and no rounded median backwardly bulging area.
    d. Posterior border of carapace evenly convex from side to side; opisthosoma short, its greatest width nearly equal to its median length; no trace of tubercles on the anterior terga of the opisthosoma . . *eggintoni*.
    d'. Posterior border of carapace with its median area nearly straight, transverse, its lateral portions also nearly straight and inclined obliquely inwards and backwards from the angles; opisthosoma long, its greatest width only equal to the median length of the anterior eight segments; a pair of tubercles in the middle of the anterior six terga . . *tuberculatus*.
a'. Carapace distinctly longer than wide; width of the anterior four sternal plates of the opisthosoma nearly equal to the length of the posterior three.
  e. Width much more than one-third of the total length; anterior four terga of opisthosoma sinuous . . . . . *angustus*.
  e'. Width about one-third of the total length; only the anterior two terga of the opisthosoma sinuous . . . . . *torpedo*.

Geraphrynus angulatus, sp. nov. Plate III, fig. 2; Text-figures 19, 20.

Carapace closely granular, with median eyes distinct and placed apparently on a tubercle which has a convex anterior border; its posterior width a little exceeding its median length; its posterior border produced and convexly rounded in the middle, its sides slightly concave; the median area of the carapace about equal to that of the anterior eight tergal plates of the opisthosoma. The median area of the first two terga of the opisthosoma almost obliterated and overlapped by the median backward projection of the carapace; the posterior border of the third nearly straight; no large tubercles traceable upon the middle of the anterior six terga; the median length of the sixth a little exceeding half that of the seventh and a little less than half the median length of the eighth; the median length of the latter about half that of the ninth, the anterior width of the ninth rather less than two-thirds that of the sixth; the median length of the ninth about equal to its

anterior width. The posterior borders of the seventh and eighth distinctly angled in the middle line. On the seventh, eighth, and ninth terga a distinct integumental groove running from the anterior to the posterior border and representing apparently the external of the two pairs of grooves seen in other species, the internal grooves dividing the terga into three definite areas being invisible in *G. angulatus*.

First sternal plate of opisthosoma much longer than the second or third in the middle line; its posterior border emarginate; the second short, its median length about one-fourth its posterior width, narrower laterally, its anterior border fitting into the emargination of the posterior border of the first; the third only a little longer than the second in the middle line, its anterior borders lightly biangulate,

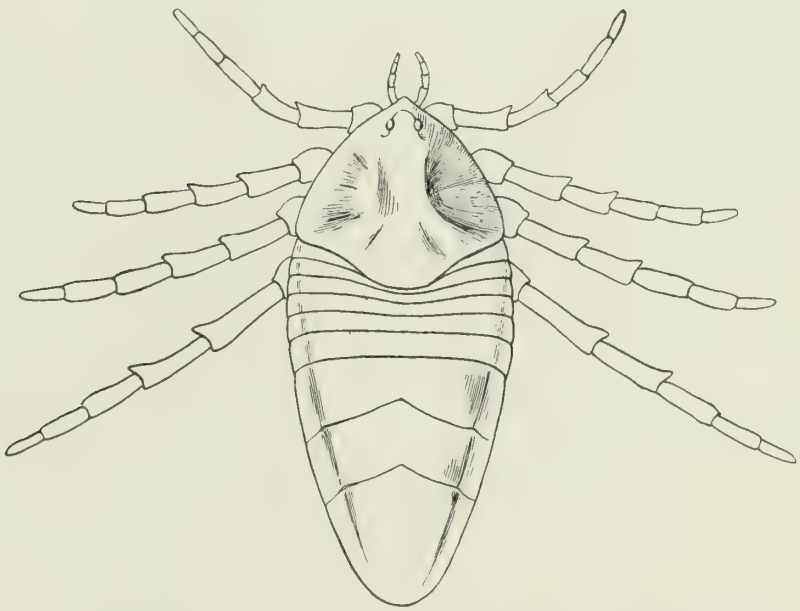


Fig. 19.—*Geraphrynus angulatus*, sp. n.; dorsal surface with appendages, four times nat. size.—Coal Measures; Coseley, near Dudley. Wheelton Hind Collection.

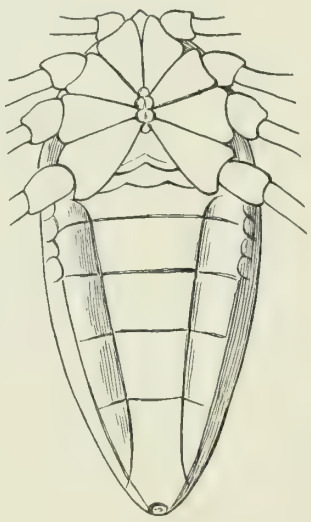


Fig. 20.—Ventral surface of the same.

its median length about half that of the fourth; the fourth, fifth, and sixth increasing gradually but slightly in length, but the sixth only a little longer than the fourth and barely two-thirds the length of the seventh.

Leg of first pair with trochanter, femur, patella and tibia about equalling the carapace in length; the same segments of the fourth leg equalling the last five terga or four sterna of the opisthosoma; the spiniform process on the distal inferior edge of the femora and patellæ apparently smaller than in other species (*e. g. G. hindi*) where they are shown.

Measurements in mm.—Total length 16; median length of carapace 6, width of latter 6·5; median length of opisthosoma about 10; width of the latter 7·5; length of sternal surface of opisthosoma 13; length of first leg from base of trochanter to end of tibia 5·5; the same segments of the fourth leg 9·5.

Coseley, near Dudley.
Type and only known specimen in the Collection of Dr. Wheelton Hind.

Geraphrynus hindi, sp. nov. Text-figures 21, 22.

Carapace of about the same shape as in *G. angulatus*. The anterior five terga of the opisthosoma more sinuous transversely, the lateral portion of the anterior borders slightly convex and the median areas slightly concave. In *G. angulatus* the third is scarcely sinuous, and the fourth is straight transversely. The posterior portion of the opisthosoma relatively much wider than in *G. angulatus*; the posterior border of the penultimate or eighth sternal plate about as long as the carapace and

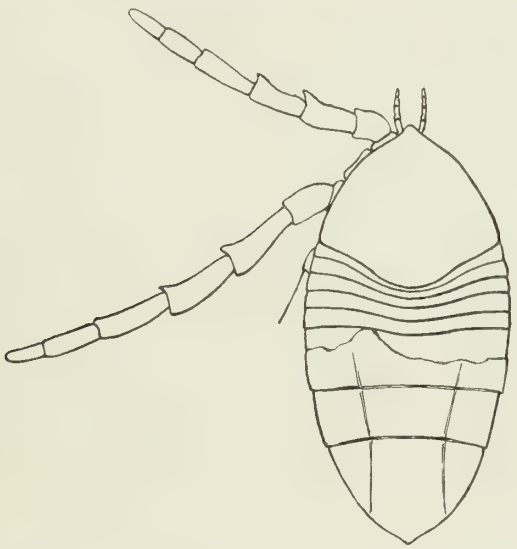


Fig. 21.—*Geraphrynus hindi*, sp. n.; dorsal surface with palpi and legs of first and third pairs, four times nat. size.—Coal Measures; Coseley, near Dudley. Wheelton Hind Collection.

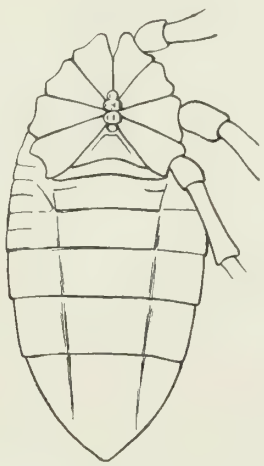


Fig. 22.—Ventral surface of the same.

a little greater than the median length of the eighth and ninth sternal plates; the posterior width of its median area much greater than its length. In *G. angulatus*, on the other hand, the posterior width of the plate is much less than the length of the carapace or than that of the eighth and ninth sterna, and the posterior width of its median portion is about equal to its length. Legs much longer than in *G. angulatus*, the trochanter, femur, patella and tibia, *i. e.* the second, third, fourth, and fifth segments of the third leg, exceeding the median length of the opisthosoma. In *G. angulatus* these same segments in the fourth leg are much shorter than the median length of the opisthosoma, and since the fourth leg in this genus is longer than the third, it is evident that the segments in question in the fourth leg of *G. hindi* would greatly exceed the median length of the opisthosoma.

Measurements in mm.—Total length 13; length of carapace 5, width 5·5; median length of opisthosoma 8, width of opisthosoma 7; length of ventral surface of opisthosoma from apex of first sternal plate 11; length of first leg, excluding coxa, 8, of third leg 11.

Coseley, near Dudley.

Type and only known specimen in the Collection of Dr. Wheelton Hind.

Geraphrynus tuberculatus, sp. nov. Text-figure 23.

Carapace thickly and closely granular, short, much wider than long, its median length about equal to that of the first seven tergal plates of the opisthosoma; its

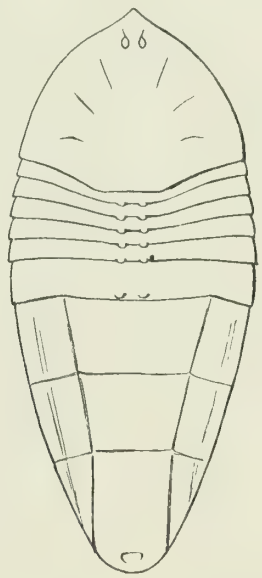


Fig. 23.—*Geraphrynus tuberculatus*, sp. n.; dorsal surface, four times nat. size.—Coal Measures; Coseley, near Dudley. W. Egginton Collection.

posterior border straight and transverse, in no sense convex, in the middle, almost straight and inclined obliquely forwards and outwards at the sides. The anterior six tergal plates of the opisthosoma each with a pair of distinct tubercles in the middle; the first and second curved round the posterior edge of the carapace; the third with its posterior border nearly straight; the median area of the first quite distinct; the sixth nearly twice as long as the fifth, and about half the length of the seventh or eighth; the latter about two-thirds the length of the ninth, the anterior width of which is about two-thirds the width of the sixth; the length of the ninth about three-quarters its anterior width. The posterior borders of the median area of the seventh and eighth terga straight, not angled.

Ventral surface and appendages unknown.

Measurements in mm.—Total length 18; length of carapace 6, width nearly 8; median length of opisthosoma 12, width of opisthosoma 8·5.

Coseley, near Dudley.

Type in the Collection of Mr. Walter Egginton (No. 46).

Mr. Egginton's Collection also contains a specimen measuring about 20 mm. long, which possibly belongs to this species, but is not sufficiently well preserved for description.

Geraphrynus eggintoni, sp. nov. Text-figures 24, 25.

Carapace about as wide as long; its median length about equal to that of the anterior eight tergal plates of the opisthosoma; its posterior border convex in the middle, but not produced, its lateral portion not concave or sinuous. Median area of first and second tergal plates of opisthosoma very narrow; posterior border of the third straight; the sixth nearly twice the length of the fifth, and about half

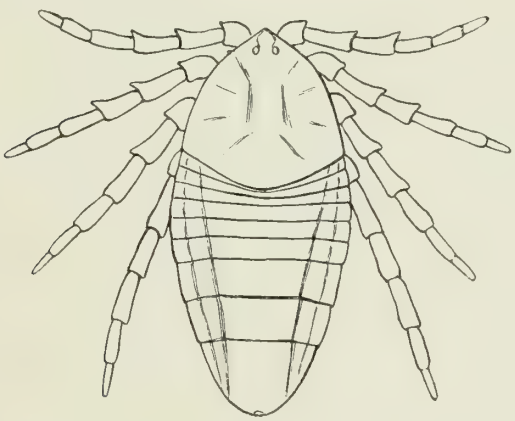


Fig. 24.—*Geraphrynus eggintoni*, sp. n.; dorsal surface with appendages, four times nat. size.—Coal Measures; Coseley, near Dudley. W. Egginton Collection.

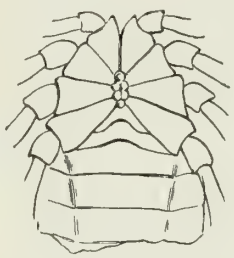


Fig. 25.—Ventral surface of prosoma and of anterior somites of opisthosoma of the same.

that of the seventh; the posterior border of the seventh and eighth straight; median area of seventh and eighth subequal and about two-thirds that of the ninth, the anterior width of which is about three-fourths the width of the seventh, and much greater than the median length of the ninth. On the ventral surface the first sternal plate seems to be much shorter in the middle line than in *G. angulatus* or *G. hindi*, owing to its deeper emargination; the second also is shorter than in the former species, more produced mesially in front and more emarginate behind, while the third is apparently much longer, being in fact as long in the middle line as the fourth. Legs short, that of the first pair with its trochanter, femur, patella and tibia about equal to the length of the carapace; the spines on the femur and patella well marked; trochanter, femur and patella of the third about equal to the carapace; the same segments and the tibia of the third about equal to the last five segments of the opisthosoma.

Measurements in mm.—Total length 12; length and width of carapace 5; median

length of opisthosoma 7, width of the latter about 6; length of first leg from base of trochanter 7, same of the third leg 8.

Coseley, near Dudley.

Type and only known specimen in the Collection of Mr. Walter Egginton.

This species has the legs short as in *G. angulatus*, but differs in the shape of the posterior border of the carapace, and of the seventh and eighth terga of the opisthosoma, this region also being shorter and broader than in that species. From *G. hindi* it differs in the shortness of its legs and the shape of the posterior border of the carapace, and from *G. tuberculatus* in its longer carapace, shorter opisthosoma, shape of the posterior border of the carapace, etc.

Geraphrynus torpedo, sp. nov. Plate III, fig. 1; Text-figures 26, 27,

Body long and narrow, nearly four times as long as wide. Carapace about

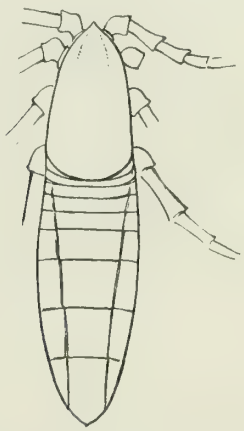


Fig. 26.—*Geraphrynus torpedo*, sp. n.; dorsal surface, about four times nat. size.—Coal Measures; Coseley, near Dudley. W. Egginton Collection.

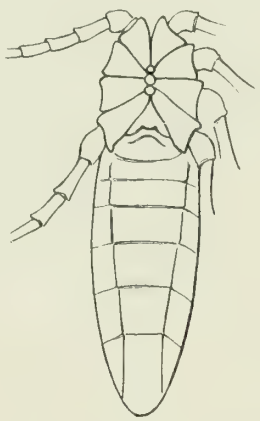


Fig. 27.—Ventral surface of the same.

one-third longer than wide, its median length about equal to that of the anterior eight terga of the opisthosoma, its width about equal to the length of the ninth and half the eighth terga, and therefore much less than half the length of the opisthosoma; its posterior border evenly convex. Opisthosoma nearly twice as long as wide, its width across the seventh tergum a little exceeding the length of the eighth and ninth terga; the first and second terga very narrow in the middle line, the median area of the first obliterated or overlapped by the posterior border of the carapace, the third, fourth and fifth straight and subequal in length, the fifth about half the length of the sixth, which is a little more than half the length of the seventh, the latter about equal to the eighth, and both of them shorter than the ninth. Fifth and sixth sterna of the opisthosoma subequal in length and shorter than the seventh; the sternal plate, corresponding to the third in the typical species of *Geraphrynus*, as long as the fourth and marked by a transverse ridge;

the second segment also long, with the median area of its anterior border considerably produced to fit into the correspondingly deep emargination of the first triangular intercoxal sternal plate. Coxal area of prosoma about one-fourth longer than wide. Leg of first pair apparently shorter than the carapace, which is about as long as the trochanter, femur, patella and tibia of the fourth leg.

Measurements in mm.—Total length 12; carapace almost 5, width of carapace 3; length of opisthosoma 7, width about 4; length of its last three segments about 5; of sternal area of opisthosoma nearly 10; width of coxal area of prosoma 3·5; length of fourth leg almost 7.

Coseley, near Dudley.

Type and only known specimen of this aberrant species in the Collection of Mr. Walter Egginton (No. 10).

Geraphrynus angustus, sp. nov.

Allied to the last but shorter; body about two and a half times as long as wide. Carapace about one-fourth longer than wide, median length equal to that of the anterior eight terga of the opisthosoma, its posterior border evenly and widely convex. Opisthosoma much less than twice as long as wide, its width about equal to the last three tergal plates; the first, second, third and fourth terga sinuously curved round the convex border of the carapace; the median area of the first obliterated, of the second very short; the anterior border of the fifth sinuous; the plate about half the length of the sixth, which is more than half that of the seventh; seventh and eighth subequal and each about three-quarters the length of the ninth.

Measurements in mm.—Total length 9·5; length of carapace 4, width 2·5; length of opisthosoma 5·5, width 3·8; length of sternal area of opisthosoma 7·5.

Coseley, near Dudley.

A single specimen in Mr. Walter Egginton's Collection (No. 36, one half labelled also 26).

In addition to its greater width as compared to its length, a character in which it serves in a measure to bridge over the interval between *G. torpedo* and the more normal species of *Geraphrynus*, this new species differs from *G. torpedo* in the sinuous curvature of the anterior four terga of the opisthosoma.

Order ANTHRACOMARTI, Karsch.

1882. *Anthracomarti*, F. Karsch (in part).
1885. *Meridogastra*, T. Thorell (as substitute for Anthracomarti).
1884 and 1890. *Anthracomarti*, S. H. Scudder (in part).
1890. *Anthracomarti*, E. Haase (*sensu stricto*, as Suborder of Opiliones).

1902–3. *Anthracomarti*, R. I. Pocock (*sensu stricto*).
1904. *Pleuraraneæ*, A. Fritsch (as Suborder of Araneæ).
1904. *Meridogastra* (= Anthracomarti), A. Fritsch (in part as Suborder of Opiliones).

Prosoma covered dorsally by a carapace consisting of a single plate, variable in form, but very generally marked posteriorly with a transverse groove indicating the line of fusion between the tergal plate of the sixth somite and those of the preceding five. No movable plate in front overhanging the cheliceræ. Eyes, when traceable, two in number.

Appendages of the first pair (cheliceræ) unknown. Those of the second pair (palpi) simple and pediform and consisting of six segments; those of the remaining four pairs similar in form, ambulatory in function, and consisting of seven segments. The basal segments or coxæ of the palpi and ambulatory limbs, *i. e.* of the five pairs of post-oral appendages, large, triangularly wedge-shaped, but movable and arranged round the narrower or wider sternal area, which was furnished with a median elongate sternal sclerite. Mouth-parts unknown.

Opisthosoma without appendages, movably jointed to the prosoma, but with its individual segments apparently welded together, though the sutural lines persist. Seven tergal plates are always traceable on the dorsal side, the first of the seven (*i. e.* the seventh counting forwards from the posterior end) being almost invariably longer than those that succeed it; each tergum is marked on each side with a longitudinal sulcus or groove which separates a lateral lamina from the median area of the tergum; sometimes there is a second sulcus nearer the external margin than the one just mentioned; hence each tergum is divided into either three or five distinct areas according to the number of sulci. In front of the seventh tergum from the end, either one or more tergal sclerites may be traced; these are usually not provided with lateral laminæ and may be overlapped more or less by the posterior border of the carapace; they appear to represent from one to three additional tergal plates undergoing excalation. The last tergal plate on the dorsal side, that is to say the seventh, not counting the variable number of anterior tergal plates just mentioned, is the narrowest of the series; but it is almost invariably provided with an unpaired posteriorly-expanding median lamina, in addition to its paired laminæ, with which it forms a continuous series; this lamina is itself sometimes marked off by a transverse sulcus from the median area of the tergum. This median lamina of the last tergum visible from the dorsal side, overlaps the tergal element of the next succeeding segment; the tergum of this segment is fused with its sternal element to constitute a subannuliform sclerite, near the centre of which lies a plate, the anal operculum, which is the tergal element of the last segment. Thus ten tergal elements may be traced with certainty in almost all genera, the last being the anal operculum and the first the short tergal area that lies between the carapace and the first large tergal plate of invariable occurrence, namely the seventh from the end on the dorsal side.

The sternal elements of the opisthosoma appear to correspond in number with the terga, except that, with the doubtful exception of *Eophrynus*, there is no sternal plate to represent the tenth tergum or anal operculum. Hence there are nine sternal plates in all, the last being the ventral element of the plate surrounding the anal operculum. The anterior sterna are variously modified and arranged according to the genus, the arrangement in *Anthracomartus* being very different from that of *Eophrynus*, the first, whether large as in the former or small as in the latter, being probably the genital operculum.

The morphology of the anterior region of the opisthosoma in this Order opens a wide field for speculation. I have already suggested two hypotheses to account for the facts, either or neither of which may represent the actual truth (see Geol. Mag. [4], vol. ix, pp. 443—448, 1902, and vol. x, pp. 250—251, 1903). But since seeing examples of *Anthracomartus* with its enlarged and posteriorly-projecting first sternal plate, which recalls so forcibly the genital operculum of the Pedipalpi, I am inclined to the opinion that my first-published view is probably correct, namely, that the genital orifice opened behind the first sternal plate in *Eophrynus* and *Anthracomartus*. This sternal plate, therefore, will be the sternum of the genital segment, the tergum of which is apparently the short first tergal plate, which is sometimes partially or wholly overlapped by the hinder border of the carapace. The tergal element of the pregenital segment seems to be present both in *Eophrynus* and *Kreischeria;* but I have not been able to recognise its sternal region in these genera, although in *Anthracomartus* there seems to be a comparatively large unchitinised area between the first sternal plate of the opisthosoma (the genital operculum) and the sternal plate of the prosoma.

The British genera referred to this Order appear to fall into the following four groups:

(1) *Brachypyge; Maiocercus.*

(2) *Anthracomartus.*

(3) *Anthracosiro; Trigonotarbus.*

(4) *Eophrynus; Kreischeria; Aphantomartus.*

In 1902 I proposed to refer the genera *Brachypyge* and *Anthracomartus* to the family Anthracomartidæ, and *Eophrynus* and *Kreischeria* to the Eophrynidæ. To these I added in 1903 the family Anthracosironidæ for *Anthracosiro*. At that time, however, I had not seen representatives of the genera *Anthracomartus*, *Kreischeria*, and the two described below as *Trigonotarbus* and *Aphantomartus*. The structure of the carapace shows that *Aphantomartus* belongs to the same category as *Eophrynus* and *Kreischeria*, and that *Trigonotarbus* is apparently related to *Anthracosiro*. On the other hand, the structure of the ventral surface of the opisthosoma in *Anthracomartus* is very different from that of *Eophrynus* and *Trigonotarbus*, the only other genera of the order in which this region has been

observed, yet the carapace of *Anthracomartus* is, generally speaking, like that of *Anthracosiro* and *Trigonotarbus*.

Of *Brachypyge*, as exemplified by the type species *B. carbonis*, only the dorsal surface of the opisthosoma is known. Of the second species, which has been referred to the genus, namely, *B. celtica*, only the ventral area of the opisthosoma has been described and figured. These two species resemble each other, and differ from the rest of the Anthracomarti in the production of the angles of the pleural plates into spiniform processes. The two species are probably, but certainly not closely, allied, and there are good grounds for regarding them as distinct genera. There seem to me to be no justifiable reasons for assuming that the anterior sterna of the opisthosoma of *B. celtica* have been wrongly depicted. If correctly drawn, they differ greatly from the corresponding plates of *Anthracomartus*. On the strength of this difference, supplemented by the peculiar formation of the margins of the pleural plates, above alluded to, I am now disposed to separate *Brachypyge* from the family Anthracomartidæ, and erect for its reception the family Brachypygidæ. For *Anthracosiro* and *Trigonotarbus* the name Anthracosironidæ may be retained; while the Eophrynidæ will comprise *Eophrynus*, *Kreischeria*, and *Aphantomartus*.

The four families may be distinguished as follows:

a. Margins of the pleural laminæ concave with spiniform angles; pleural laminæ large and divided as in the Anthracomartidæ, but the anterior sterna of the opisthosoma, where known, not enlarged and backwardly produced . . . *Brachypygidæ*.

a'. Margins of the pleural laminæ of the opisthosoma convex, the angles not produced.

b. Carapace of prosoma not markedly sulcate except posteriorly; its lateral and anterior portions sloped gradually or steeply downwards to the margin.

c. Opisthosoma with very large pleural laminæ, each of which is divided into an external and an internal moiety by a sulcus visible on the dorsal and ventral sides; the anterior sternal plates swollen and produced backwards in the middle line and furnished on each side with a deep depression; the posterior sternal plates produced forwards and mesially angular *Anthracomartidæ*.

c'. Opisthosoma with its pleural laminæ small or moderate and undivided, not defined by a sulcus on the ventral side; anterior sterna small, not backwardly produced and not deeply impressed laterally; posterior sternal plates not angularly notched in the middle line . . *Anthracosironidæ*.

b'. Carapace of prosoma transversely sulcate; its lateral portions extended as a horizontal sulcate lamina considerably beyond the elevated median portion; opisthosoma with pleural laminæ undivided, its sterna as in the Anthracosironidæ . . . . . *Eophrynidæ*.

Family Brachypygidæ, nov.

Characters as above.

I refer the two known species of this family to the following genera, which may be distinguished thus:

a. Opisthosoma much longer than wide; pleural laminæ of the second and third pleura-bearing terga inclined slightly backwards . . . . . *Brachypyge*.

a'. Opisthosoma much wider than long; pleural laminæ of the first, second, third, and fourth sterna inclined slightly forwards . . . . . *Maiocercus*.

Genus **BRACHYPYGE**, H. Woodward.

1878. *Brachypyge*, H. Woodward, Geol. Mag. [2], vol. v, pp. 433—436, pl. xi.
1902. *Brachypyge*, R. I. Pocock, Geol. Mag. [4], vol. ix, pp. 488, 491.
1904. *Brachypyge*, A. Fritsch, Palæoz. Arachn., p. 41.

Type Species.—Brachypyge carbonis, H. Woodward.

Brachypyge carbonis H. Woodward. Text-figure 28.

1878. *Brachypyge carbonis*, H. Woodward, Geol. Mag. [2], vol. v, pp. 433—436, pl. xi; also Bull. Acad. Roy. Belg. (2), vol. xlv, no. 4, pp. 410—415, with plate.

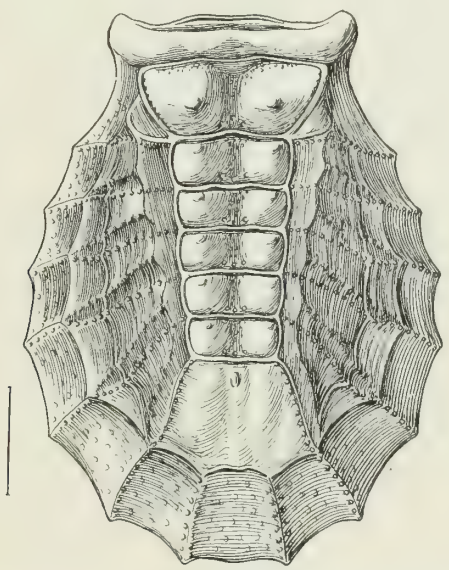


Fig. 28.—*Brachypyge carbonis*, H. Woodward; dorsal surface of opisthosoma, five times nat. size.—Coal Measures; Mons, Belgium. After H. Woodward, Geol. Mag. [2], vol. v, pl. xi.

1885. *Anthracomartus carbonis*, S. H. Scudder, C. R. Soc. Ent. Belg., vol. xxix, pp. 84—85.
1887 and 1896. *Eophrynus carbonis*, H. Woodward, Geol. Mag. [3], vol. iv, p. 49; also Quart. Journ. Geol. Soc., vol. lii, p. cix.
1902. *Brachypyge carbonis*, R. I. Pocock, Geol. Mag. [4], vol. ix, p. 488.
1904. *Brachypyge carbonis*, A. Fritsch, Palæoz. Arachn., p. 42.

Only the dorsal area of the opisthosoma is known. Judging from the figure this shows the following interesting structural characters: There are eight well-defined tergal plates. The first is short; but it is wider than the anterior border

of the second; it has no laminæ, but bears two widely separated tubercles. A pair of similar but larger tubercles is present on the elevated median area of the six following terga. The second tergal plate is large; its pleural laminæ are distinct, with their postero-lateral portion inclined outwards and slightly backwards. The pleural laminæ from the third to the seventh are widely extended laterally and divided by a distinct sulcus into an external and internal moiety. The median area of the terga is narrow as compared with the same area in *Anthracomartus*. The median area of the eighth tergal plate is very long and the inner moieties of the pleural laminæ are not differentiated. In this respect *B. carbonis* differs from all the other members of the Anthracomarti hitherto described; and it is the elongation of the tergal plate which gives the characteristic length to the opisthosoma.

Genus **MAIOCERCUS**, nov.

Characters as above (p. 59).

Type Species.—Maiocercus celticus, Pocock.

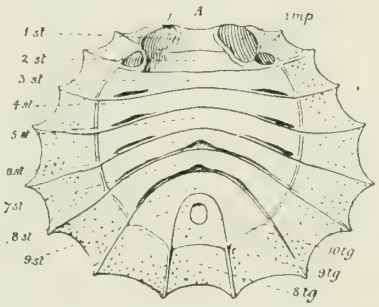


Fig. 29.—*Maiocercus celticus* (Pocock); ventral surface of opisthosoma, nat. size.—Coal Measures; Ty'nybedw, Rhondda Valley, S. Wales. *1 st.* to *9 st.*, sterna of the first to the ninth somites; *8 tg.*, ventral side of median lamina of the last tergal plate visible on the dorsal side; *9 tg.*, area regarded as the tergal plate of the ninth somite; *10 tg.*, anal operculum or tergal plate of the tenth somite; *imp.*, impression (? coxal) marking the first and second sternal plates. From Geol. Mag. [4], vol. ix, p. 491.

Maiocercus celticus (Pocock). Text-figure 29.

1896. *Eophrynus carbonis*, F. T. Howard and T. H. Thomas, Trans. Cardiff Nat. Hist. Soc., vol. xxviii, p. 52, figs. *a* and *b* (*nec* Woodward).

1902. *Brachypyge celtica*, R. I. Pocock, Geol. Mag. [4], vol. ix, p. 488, fig. 2 *a*.

1904. *Brachypyge celtica*, A. Fritsch, Palæoz. Arachn., p. 41.

The figure of the ventral surface of the opisthosoma of this species suggests that the genus *Maiocercus* is much more closely allied to *Anthracomartus* than is *Brachypyge*. The chief resemblance to *Brachypyge* lies in the scalloped edge of the pleural laminæ. There is no reason to suppose that the eighth somite is elongated as in the latter. The posterior borders of the sixth and seventh sterna show the

mesial angular notch present in *Anthracomartus*, but the first and second sternal plates are not enlarged and posteriorly produced as in *Anthracomartus*. There is, however, on each side of them a distinct impression which I suggested in 1902 indicated possibly the position of the coxæ of the legs of the last pair.

Family Anthracomartidæ, Haase.

(= *Anthracomartidæ* + *Promygalidæ*, Fritsch.)

Carapace of prosoma not differentiated into definite regions as in the Eophrynidæ, at most marked by a single posterior transverse sulcus. Cheliceræ not certainly known, but apparently very slender, with thin, rod-like basal segments. The remaining appendages normal, with their basal segments arranged subradially round a wide sternal area; sternal plate unknown. Opisthosoma with its lateral and posterior borders forming a continuous widely-rounded curve, exhibiting eight tergal plates on the dorsal side; the first very short, narrowed laterally, without pleural laminæ, and partially or wholly overlapped by the posterior border of the carapace; the rest with very large pleural laminæ, divided into an outer and an inner plate by sulci; these sulci form a continuous series passing round the opisthosoma in a line concentric with the lateral and posterior borders, starting at the antero-lateral angles of this region in front and cutting posteriorly the unpaired median pleural lamina of the last tergal plate on the dorsal side. The median area of the first large pleura-bearing tergal plate usually widened in front. In the posterior half of the opisthosoma the pleural laminæ are directed obliquely backwards, so that the posterior borders of the terga form a strongly curved line, concave backwards.

On the ventral surface nine sternal areas are distinctly traceable in front of the anal operculum. The posterior borders of the fifth to the eighth are strongly recurved and notched in the middle line, giving a marked and characteristic angular appearance to these plates. The first visible sternal plate, no doubt the genital operculum, is large and wide, with concave anterior border and a more or less angularly produced posterior border. It lies well behind the coxæ of the posterior limbs of the prosoma and is in no sense wedged in between them as in the Eophrynidæ. Usually, at all events, it has a median ridge or prominence. The second and third plates follow, roughly speaking, the curvature of the first, their posterior borders being convex backwards. The third plate is sharply marked off from the fourth by what appears to be a strong hinge. Passing obliquely backwards and inwards from the lateral portion of the third plate towards the anal operculum, there is, on each side, a strong ridge. The sternal areas between these ridges are depressed so that the middle of the ventral surface behind the third sternal plate is arched. Outside these ridges the ventral surface is sloped obliquely

upwards to the inner edges of the pleural plates, the pleural plates themselves lying more in a horizontal plane. When directed backwards the fourth leg lies apparently in the space beneath the pleural plates and against the upsloping external area of the ventral surface. In front of the first sternal plate, and between it and the sternum of the prosoma, with the coxæ of the legs of the last pair on each side, there is a longer or shorter area which was probably membranous. This, perhaps, represents the sternal region of the pre-genital segment, which seems to be unrepresented on the dorsal side of the opisthosoma. The sulcus on the dorsal side, which cuts the laminæ into two moieties, is represented on the sternal side by a similar sulcus following the curvature of the lateral and posterior borders of the opisthosoma.

I believe the above-given interpretation of the ventral surface of the opisthosoma to be, approximately at all events, correct. But in no specimen that I have seen is the ventral surface exposed fully from below. In every case where the sternal plates are well shown it is their inner surface that is exposed—that is to say, the organism is split in two in such a way that the dorsal area is seen from below and the ventral area from above. Hence in my description of the ventral skeletal plates I have interpreted grooves and hollows as ridges and elevations respectively, and *vice-versâ*. This opens up possibilities of error which must not be lost sight of; and when discussing *Promygale* and *Anthracomartus* in the November issue of the Geological Magazine for 1910, I inadvertently fell into the error of describing a deep groove on each side of the lower surface of the opisthosoma. The structure should have been described as a ridge.

The Anthracomartidæ are sharply distinguished from the Eophrynidæ and from the Anthracosironidæ, as exemplified respectively by *Eophrynus* and *Trigonotarbus*, not only by the structure of the anterior sternal plates of the opisthosoma, but also apparently by the separation of the pleural plates into an outer and an inner moiety by sulci, which are apparent upon the ventral as well as upon the dorsal surfaces. They further differ from the Eophrynidæ, but not from the Anthracosironidæ, by the structure of the carapace of the prosoma.

Genus **ANTHRACOMARTUS,** Karsch (emend.).

1882. *Anthracomartus*, F. Karsch, Zeitschr. deutsch. geol. Ges., vol. xxxiv, p. 556.
1885. *Anthracomartus*, S. H. Scudder, Proc. Amer. Acad. Arts Sci., vol. xx, p. 17.
1890. *Anthracomartus*, E. Haase, Zeitschr. deutsch. geol. Ges., vol. xlii, p. 645.
1901. *Promygale*, A. Fritsch, Fauna der Gaskohle, vol. iv, p. 58.
1902. *Anthracomartus*, R. I. Pocock, Geol. Mag. [4], vol. ix, p. 491.
1904. *Anthracomartus*, A. Fritsch, Palæoz. Arachn., p. 36.
1904. *Promygale*, A. Fritsch, Palæoz. Arachn., p. 19.
1910. *Anthracomartus*, R. I. Pocock, Geol. Mag. [5], vol. vii, pp. 504—508.

Generic Characters.—Carapace high; the median portion of its upper surface nearly flat or slightly excavated; the lateral and anterior portion sloped nearly vertically downwards to the lateral and anterior border; the posterior portion much more gradually sloped backwards to the groove which defines the posterior border; this border straight or slightly emarginate; the postero-lateral angles rectangular; the lateral borders subparallel for more than half their length, but converging anteriorly from a point approximately on a level with the articulation of the legs of the second pair, to form an angular prominence over the mandibles; the edges of the flattened dorsal area defined by a marked ridge which exhibits anteriorly a low and short crest or thickening, perhaps marking the position of the lateral eyes; the descending portion in the middle line in front compressed or defined by a pair of grooves which pass downwards to the marginal angle above the mandibles.

Opisthosoma and limbs constructed as described under the diagnosis of the family.

Type Species.—*Anthracomartus voelkelianus*, Karsch, from the Coal Measures of Silesia.

Generic value has been assigned to the characters presented by the carapace, because it appears to me probable that *A. palatinus*, Ammon, if the figure is to be trusted, will have to be separated from *Anthracomartus* on account of the difference in the shape of the carapace, which is much wider than long, somewhat constricted posteriorly, and has the antero-lateral angles widely rounded. Moreover, the antero-lateral angles of the opisthosoma project prominently beyond the postero-lateral angles of the carapace. Ammon detected a pair of median eyes near the front of the upper surface of the carapace in his species. No such eyes were seen in any of my specimens.

It is needless to repeat here the reasons I have already published for regarding *Promygale* as a synonym of *Anthracomartus* (see Geol. Mag. [5], vol. vii, pp. 505—508, 1910).

The chief distinctive features of the two species of this genus described below may be briefly epitomised as follows:

a. Total length of adult from about 21 to 25 mm.; seventh tergal plate of opisthosoma larger, the length of its median area approximately equal to its anterior width; the triangular lateral pleural plate correspondingly long . . . . *hindi*.

a'. Total length of adult from about 10 to 12 mm.; seventh tergal plate of opisthosoma smaller, the length of its median area much less than its anterior width; the triangular lateral pleural plate correspondingly short . . . . *priesti*.

Neither of these can be identified, at present, with any described form.

Anthracomartus hindi, sp. nov. Plate III, fig. 3; Text-figures 30—32.

Carapace about as long as wide or a little longer; its median length about equal to that of the anterior[1] five tergal plates of the opisthosoma; its surface, like the dorsal and ventral surfaces of the opisthosoma, finely, closely, and nearly uniformly granular throughout. The first tergal plate of the opisthosoma large; its median length nearly equal to that of the second and third taken together; the median lengths

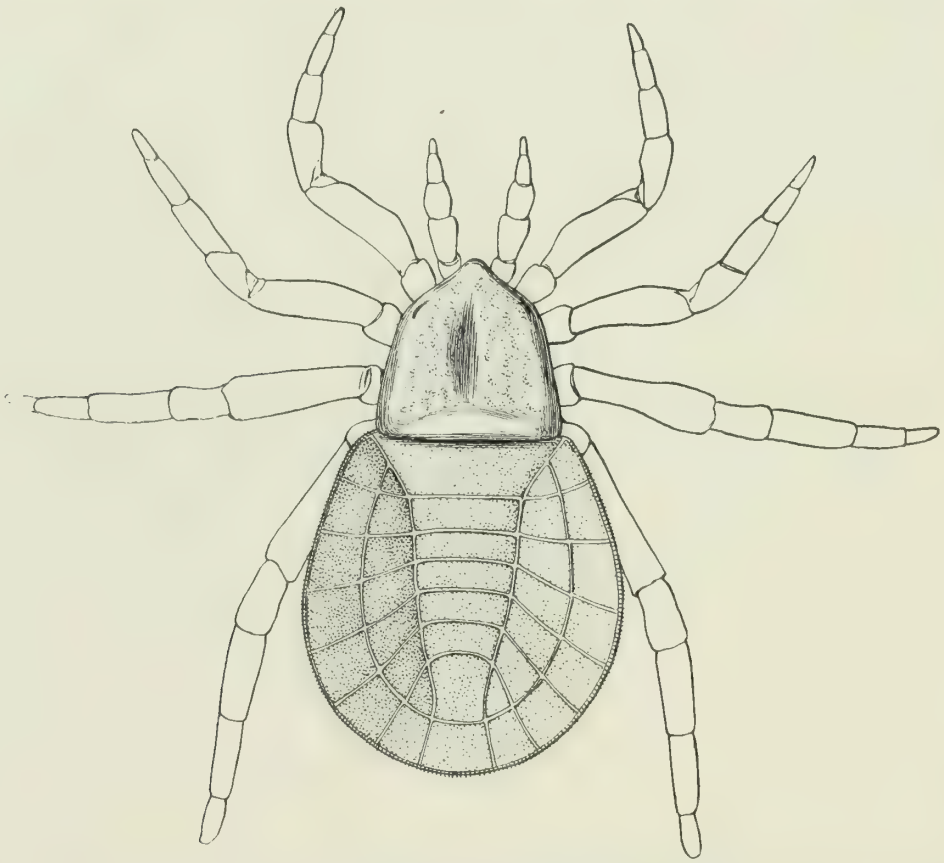


Fig. 30.—*Anthracomartus hindi*, sp. n.; restoration of dorsal surface with appendages, taken from several specimens, about two and a half times nat. size.—Coal Measures; Coseley, near Dudley.

of the second, third, fourth, fifth and sixth subequal; the posterior border of the median area of the first and second straight, of the third, fourth, fifth and sixth becoming gradually but only slightly more and more recurved; the length of the median area of the first plate about half its posterior width; of the second a little less than one third of its posterior width; the third to the sixth becoming progressively and gradually narrower, the median length of the sixth being about one-half its posterior width; median length of the seventh exceeding that of the first and

[1] In this and other cases where Anthracomartidæ are described, the first tergal plate of the opisthosoma is considered to be the seventh from the end on the dorsal side, the narrow anterior plate, which is often overlapped by the carapace, being disregarded.

equal to its own anterior width ; length of the median lamina of the seventh about two-thirds the length of that plate. Palp with femur, patella, tibia and tarsus about three-quarters the length of the carapace ; the femur and patella stout, the tibia and tarsus thinner. Trochanter and femur of first leg about as long as the first four terga of the opisthosoma ; of fourth leg about as long as the first five terga.

Measurements in mm. (of type).—Total length 25 ; length of carapace 9, width 8 ; length of opisthosoma 16, width about 16 ; median length of its first tergum 2·8, of second + third 3 ; four distal segments of palpus 6; trochanter and femur of first leg 7, the rest of the limb 8·5; trochanter and femur of second about 7, the

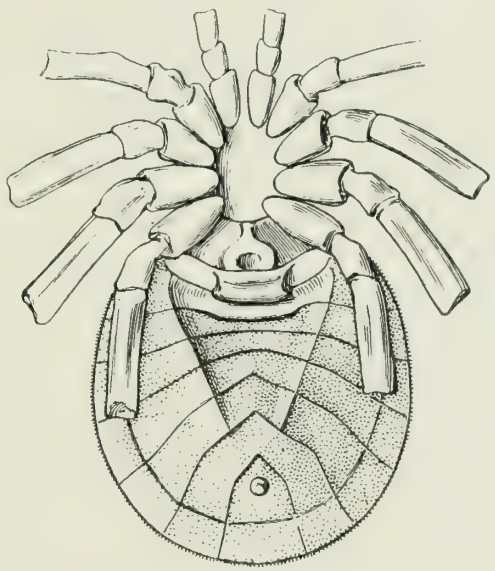


Fig. 31.—*Anthracomartus hindi*, sp. n. ; suggested restoration of the ventral surface, about two and a half times nat. size.—Coal Measures ; Coseley, near Dudley. From Dr. Wheelton Hind's specimen, No. 1.

rest of the limb 10·5 ; trochanter and femur of third about 7·5, of fourth about 8.

Dudley, and Coseley, near Dudley.

The type of this species is a cast (No. 12148), in the Geological Survey Museum, of the underside of the dorsal surface of a specimen from Dudley belonging to Dr. Kidston.

In addition to this I have seen the following specimens which may be referred to the same species.

(1) One in Dr. Hind's Collection showing the dorsal surface from the lower side and the ventral surface from the upper side, with the palpi and the four pairs of ambulatory limbs at least as far as the extremities of the femora ; also the coxæ, represented by hollow spaces, and the intervening sternal area. The first leg appears to be relatively longer than in the type and has a considerably larger angular prominence in front ; and the first tergal plate of the opisthosoma seems

to be distinctly shorter than the following two. These differences, however, are very likely sexual, the specimen under notice being perhaps the male and the type the female of the same species. The anterior sternal plates of the opisthosoma are difficult to decipher. The suggested restoration in the annexed figure may possibly, however, help their correct interpretation when other material is available. *Measurements in mm.*—Total length 22; length and width of carapace about 8; length of opisthosoma 13·5, width doubtful; length of trochanter and femur of first and fourth legs about 7.

(2) Specimen in Dr. Hind's Collection showing the dorsal surface and obscure details of the ventral sclerites, with the trochanters and femora of the four legs of the left side. The greatest width of the opisthosoma appears to be across its third segment, not across the fourth as in the type; this region is thus narrower behind; the first tergal plate of the opisthosoma is approximately only as long as the second and half the third, and the legs appear to be relatively shorter than in the other specimens, the process on the femur of the first being small. *Measurements in mm.*—Total length 23·5, length of carapace 8·5, width doubtful; length of opisthosoma 15, approximate width 14; length of trochanter and femur of first leg 6; of fourth leg 6·5.

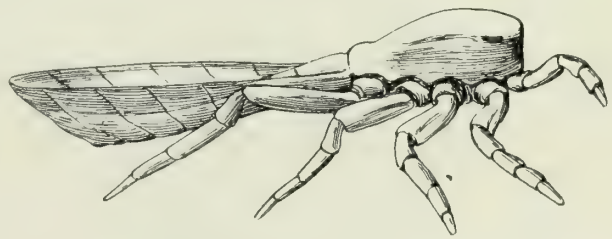


Fig. 32.—*Anthracomartus hindi*, sp. n.; suggested restoration of lateral surface, taken from several specimens, about two and a half times nat. size.—Coal Measures; Coseley, near Dudley.

This specimen, perhaps, represents a different species from the rest.

(3) Specimen in Dr. Hind's Collection showing no details of special moment. *Measurements in mm.*—Total length 21; length of opisthosoma 13, width 12.

(4) Specimen in the British Museum, collected by Mr. J. S. Neil, showing the same general features as No. 1, belonging to Dr. Hind, but less clearly. *Measurements in mm.*—Total length 21·5; length of opisthosoma 15·5.

(5) Specimen in Mr. Egginton's Collection (No. 22) showing the dorsal surface, the opisthosoma being nearly complete, but the prosoma incomplete, without trace of appendages. *Measurements in mm.*—Total length 22; length of opisthosoma 15, width doubtful.

(6) A perfect specimen of the opisthosoma in Mr. Egginton's Collection (No. 29). *Measurements in mm.*—Length of opisthosoma 15, width 14.

(7) A small specimen in Mr. Priest's Collection appears to belong to this species rather than to the following on account of the shape of the seventh tergal

plate of the opisthosoma. *Measurements in mm.*—Total length 13; length of opisthosoma 9, width about 8.

All the above-described specimens are from Coseley, near Dudley.

Anthracomartus priesti, sp. nov. Text-figures 33, 34.

Carapace apparently a little longer than wide, its median length equal to that of first six and half the seventh tergal plates of the opisthosoma; both these areas granular or coriaceous throughout. The first tergal plate of the opisthosoma large, its median length equal to that of the second and third taken together; the median lengths of the second, third, fourth, fifth and sixth subequal; their posterior borders with approximately the same curvature as in *A. hindi*; length of median

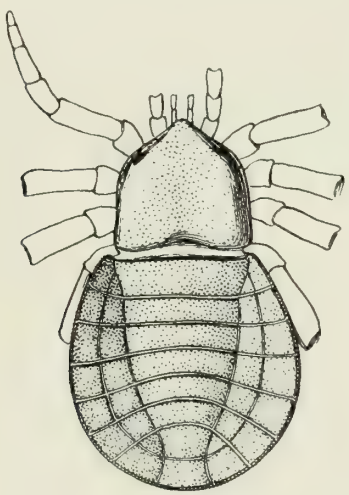


Fig. 33.—*Anthracomartus priesti,* sp n.; dorsal surface, restored from several specimens, four times nat. size.—Coal Measures; Coseley, near Dudley.

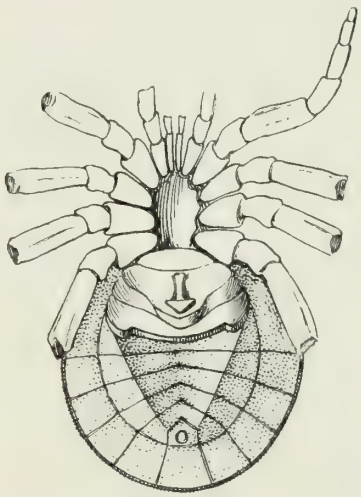


Fig. 34.—Suggested restoration of ventral surface of the same.

area of first plate less than one-half its posterior width; of the second a little more than one-fourth of its posterior width; of the sixth distinctly less than one-half its posterior width; median length of the seventh a little less than that of the first, and much less than its own anterior width; the triangular lateral laminæ of this segment nearly equal-sided; median length of the median unpaired lamina about equal to that of the seventh tergal plate itself.

Length of palpi doubtful. Trochanter and femur of first leg about equal to the median length of the first, second, third, and half the fourth terga of the opisthosoma; of fourth leg about equal to the first five terga of that region.

First sternal plate large and triangular, its posterior median angle nearly rectangular, the median area of the plate marked apparently with a somewhat arrow- or hammer-shaped crest, the handle or shaft lying in the middle line, and the head expanding laterally just in front of the angular prominence of the plate;

the second sternal plate shorter but wider than the first, with its median area elevated into a subcrescentic thickening which fits round the angle of the first; the third wider than the second, very short in the middle, thickened and notched laterally, where it is hinged to the fourth.

Measurements in mm.—Total length 11; length of carapace 4·5, width about 4; length of opisthosoma 6·5; median length of its first tergal plate about 1·3, of seventh about 1; length of trochanter and femur of first leg almost 3, of the rest of the limb 3·5; trochanter and femur of fourth leg 3·3.

Coseley, near Dudley.

The type specimen above described is in the collection of Mr. S. Priest.

In addition to the type I have seen many specimens in various stages of preservation in the Collections of Mr. S. Priest, Mr. Henry Johnson, Mr. W. Egginton, Dr. Hind, and Mr. J. S. Neil, all contained in clay ironstone nodules from Coseley and Dudley.

The following may be mentioned:

(1) A perfect specimen of the opisthosoma from the dorsal side in Mr. Priest's Collection. It differs principally from the type in having the median area of the seventh tergal plate longer than its unpaired lamina. Total length of the opisthosoma 6·5 mm., width 6 mm.

(2) Another specimen in Mr. Priest's Collection has the opisthosoma 6 mm. long and about 6·3 mm. wide.

(3) Specimen in Dr. Hind's Collection showing the same general features as the type, but the sterna of the opisthosoma less well preserved and the second, third, and fourth legs of the right side clearly traceable. The opisthosoma is shortened by distortion. *Measurements in mm.:* Total length 10; length of carapace 4·5, width 3·5; length of opisthosoma 5·5; length of second leg 5·5, of third 5·5, of fourth 6·3.

(4) Specimen in the British Museum collected by Mr. J. S. Neil and showing the dorsal surface, with the carapace incomplete. Total length about 11·5 mm.; length of opisthosoma 7 mm., width 7·5 mm.

(5) Specimen in Mr. Egginton's Collection (No. 5) showing the anterior sternal plates of the opisthosoma nearly as clearly as in the type. Total length about 12 mm., of which the opisthosoma is 7 mm; trochanter and femur of fourth leg 3 mm.

In addition to No. 5, Mr. Egginton's Collection contains ten specimens of Anthracomarti, most of which seem to belong to this species. Some, however, are of doubtful identity. The three following are selected for measurement on account of their small size: No. 26, total length 9 mm. No. 52, total length 7 mm.; length of opisthosoma 4·5 mm. No. 32, total length 5 mm.; length and width of opisthosoma about 3 mm.; length of first leg 3 mm. These may be young specimens of *A. priesti*.

Family Anthracosironidæ, Pocock.

1903. *Anthracosironidæ*, R. I. Pocock, Geol. Mag. [4], vol. x, p. 408.

Carapace of prosoma with only a single posterior transverse sulcus; elevated in the middle and sloped anteriorly, laterally and posteriorly to the borders, thus resembling in a general way that of the Anthracomartidæ. Opisthosoma with the pleural laminæ smaller than in that family and undivided, those on the anterior terga being very small. Anterior sterna of this region, at least in *Trigonotarbus*, small and crowded together, not enlarged, and posteriorly produced, the first triangular and wedged between the coxæ of the last pair of appendages, the following two or three short and not laterally impressed; the posterior border of the posterior sterna evenly convex, not mesially angled or notched.

This family constitutes in some respects an interesting connection between the Anthracomartidæ and the Eophrynidæ, resembling the former in the structure of the carapace and the latter in the shape and size of the anterior sterna of the opisthosoma.

The two genera referred to the Anthracosironidæ may be distinguished as follows:

a. Carapace rounded or truncated in front, its lateral borders only markedly converging in front of the middle; all the pleural laminæ directed obliquely backwards, their anterior and posterior borders forming distinct angles with the corresponding borders of the median area of the terga that bear them . . . *Anthracosiro*.

a'. Carapace markedly narrowed and angular in front, its lateral borders strongly converging forwards from a point behind the middle; the anterior and posterior borders of the pleural laminæ following the lines of the corresponding borders of the median area of the terga . . . . . *Trigonotarbus*.

Genus **ANTHRACOSIRO**, Pocock.

1903. *Anthracosiro*, R. I. Pocock, Geol. Mag. [4], vol. x, pp. 247–250 and 405—407.
1904. *Anthracosiro*, A. Fritsch, Palæoz. Arachn., p. 42.

Generic Characters.—Carapace high, convex from before backwards, and from side to side; its median area widely, but not deeply, excavated longitudinally, and defined by a ridge on each side, externally to which the surface slopes downwards to the lateral margin at an angle of about 45 degrees; the anterior portion of the upper surface bearing a pair of widely separated tubercles, probably oculiferous, or a transverse ridge at the ends of which eyes were probably situated; the lateral border strongly or slightly convex; the anterior border convex or nearly straight; the posterior border straight; a short area in front of the posterior border defined by a transverse groove. The opisthosoma with seven

very distinct terga, and in front of the seventh from the end (the first large tergal plate) one, or possibly two, narrower terga. The pleural plates quite small on the anterior terga, but becoming progressively longer from before backwards and tilted upwards and inclined backwards, so that the antero-lateral angle of each is obtuse and the postero-lateral angle acute; each composed of a single plate as in *Eophrynus* and *Kreischeria*, not of a double plate as in *Anthracomartus*. Appendages as in the other members of this order.

Type Species.—Anthracosiro woodwardi, Pocock.

Anthracosiro woodwardi, Pocock. Text-figures 35, 36.

1903. *Anthracosiro woodwardi*, R. I. Pocock, Geol. Mag. [4], vol. x, pp. 246—250, 405—408.
1909. *Anthracosiro latipes*, E. L. Gill, Trans. Nat. Hist. Soc. Northumb., Durham, Newcastle-on-Tyne, vol. iii, pp. 510—522, pl. xiii.

The type of this species is a specimen (No. I. 1551) in the British Museum, showing clearly the structure of the terga of the opisthosoma, portions of the walking legs and the carapace in vague outline. A second specimen (No. I. 1554) shows little more than the last, except that the radial arrangement of the coxæ of the limbs can be indistinctly deciphered. A third specimen (No. I. 1553), however, which I had not seen in 1903, has the carapace well preserved. Since this plate was previously unknown it is worth describing in detail.

It is wider than long, elevated and longitudinally convex mesially, but sloping away anteriorly, posteriorly and laterally from the highest point, which is situated near the centre of the dorsal surface. Anteriorly a distinct T-shaped ridge is traceable; the ridge representing the stem or upright portion of the letter lies in the middle line, and extends from the anterior edge of the carapace upwards to meet the ridge representing the transverse bar of the T. At each extremity of this an eye was probably situated. On each side of the median ridge there is a shallow depression. Behind the transverse ridge there extends backwards to the posterior border of the carapace a pronounced depression bordered on each side by a ridge, and constricted near the middle of the carapace so as to present the appearance of two triangular depressions set angle to angle, the posterior being much the larger of the two. Outside the ridge on each side there is a rather wide and deep longitudinal depression. Another depression, running transversely and continuous with the posterior angles of the median depression, is traceable in front of the posterior border of the carapace. Portions of the terga of the opisthosoma and of the appendages add nothing to our knowledge of these structures, with the important exception that a detached palpus shows this appendage to have been short and stout, the femur being especially strong and deep, with a rounded prominence near its base on the inferior edge.

Approximate measurements in mm.—Length of carapace 5·7, width 6; length of

palpus 7·7. The first leg is about equal to the anterior five tergal plates of the opisthosoma.

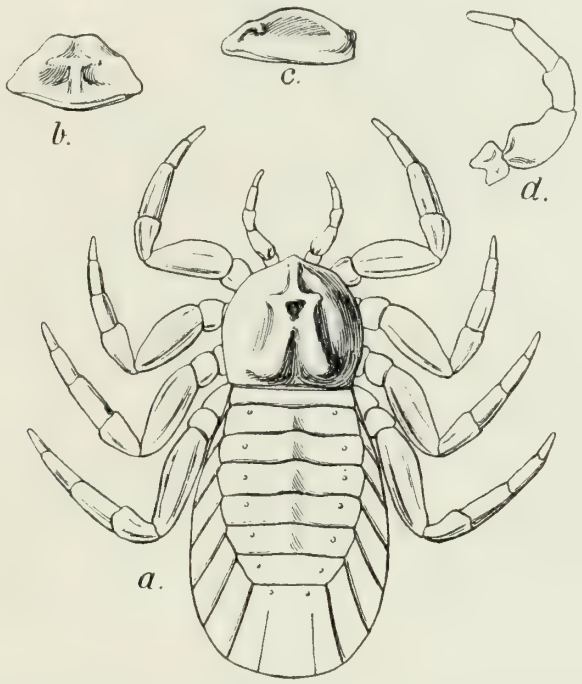


Fig. 35.—*Anthracosiro woodwardi*, Pocock. *a*. Restoration of the dorsal surface with appendages, taken from several specimens, about three times nat. size. *b*. Anterior, and (*c*.) lateral views of carapace of specimen No. I. 1553 in the British Museum. *d*. Detached palpus of the same, much enlarged.—Coal Measures; Coseley, near Dudley.

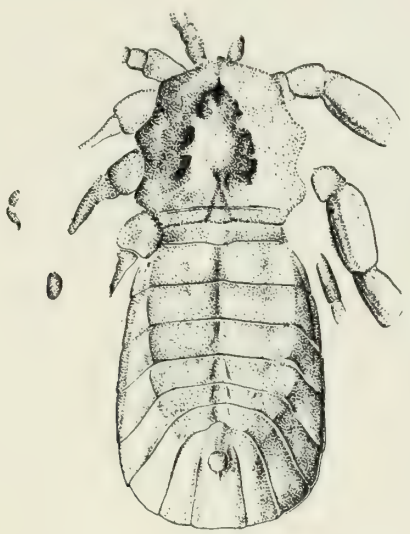


Fig. 36.—*Anthracosiro woodwardi*, Pocock; dorsal view, with the carapace crushed and the anal operculum showing through the last tergal plate visible on the upper side, about three times nat. size.—Coal Measures; Sparth, near Rochdale. W. A. Parker Collection.

In 1909 Mr. E. L. Gill described, under the name *A. latipes*, a species based upon a specimen from Crowcrook, near Newcastle-upon-Tyne, which differed apparently from the type of *A. woodwardi* in having the segments of the legs deep

and strongly compressed and crested. But by cutting away the matrix imbedding the limbs of examples of *A. woodwardi* in the British Museum, Dr. F. A. Bather has shown that the appendages are constructed as in the type of *A. latipes*. Since Dr. Bather drew my attention to this fact I have been able, through the kindness of Dr. Henry Woodward, to examine a specimen from Sparth, near Rochdale, belonging to Mr. W. A. Parker, which resembles those from Coseley and Crowcrook in the structure of the legs and in other particulars. Although Mr. Gill was perfectly justified on the evidence in describing his specimen as the representative of a new species, I think Dr. Bather is right in his belief that *latipes* must be regarded as a synonym of *woodwardi*. The specimen from Sparth shows the dorsal surface. The median ridge and the paired muscular impressions in the terga of the opisthosoma are clearly displayed. The pleural plates, however, are better preserved than in the type of *A. woodwardi* from Coseley, and those in the

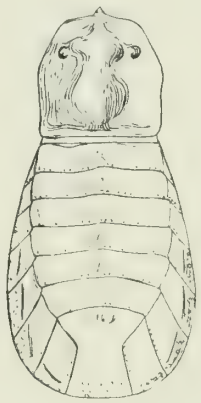


Fig. 37.—*Anthracosiro fritschi*, Pocock; dorsal surface, nearly eight times nat. size.—Coal Measures; Coseley, near Dudley. British Museum (No. I. 1556). From Geol. Mag. [4], vol. x, p. 406.

anterior portion of this region are shown to be, not triangular, as I described them, but four-sided, although the anterior margin is considerably shorter than the posterior margin. Another interesting feature to be noticed is the presence of a narrow tergal plate in front of the eighth from the end on the dorsal side as in *Eophrynus* and *Kreischeria*.

Measurements in mm.—Total length about 20; carapace about 5·5; opisthosoma, including the two narrower terga in front of the seventh from the end, 14·5—without these two terga 13; width 9; length of femur of fourth leg 4, width 2.

The known distribution of *A. woodwardi* is as follows: Coseley, near Dudley, specimens in the British Museum Nos. I. 1551 (type), I. 1553, I. 1554, formerly belonging to the Collection of Mr. H. Johnson; Sparth, near Rochdale, specimen belonging to Mr. W. A. Parker; Crowcrook, near Newcastle, the type of *A. latipes* in the Hancock Museum.

Anthracosiro fritschi, Pocock. Text-figure 37.

1903. *Anthracosiro fritschii,* R. I. Pocock, Geol. Mag. [4], vol. x, pp. 405—408, with fig.

Since no new material of this species has come to hand I can add nothing to the original description. The only known specimen measures 6·5 mm. in length.

Type in the British Museum (No. I. 1556) from the Coal Measures of Coseley, near Dudley (H. Johnson Coll.).

Genus **TRIGONOTARBUS,** nov.

Generic Characters.—Body forming an elongated oval, pointed at its anterior, rounded at its posterior end. Carapace high, markedly triangular in outline from above, widest at its posterior angles, its posterior border straight, its lateral borders slightly sinuous and converging forwards to the pointed anterior extremity. The median portion of its upper surface forming a flattish triangular area, from which the lateral and anterior portions slope somewhat abruptly away to the margin; the lateral portion hollowed posteriorly; the posterior portion of the carapace depressed and marked with a transverse groove parallel with the posterior border; the anterior sloping portion compressed. A pair of contiguous eyes on the anterior angle of the flattish area at the summit of the compressed sloping portion. Opisthosoma slightly convex between the laminæ, as wide as the carapace in front; its lateral and posterior borders forming an evenly oval curve, consisting above of seven distinct tergal plates nearly equal in length, each marked laterally with a groove defining the lateral upturned laminæ, which are smaller upon the anterior than upon the median and posterior terga, those of the first tergal plate being very small; the laminæ not directed so obliquely backwards as in *Anthracosiro.* The last tergal plate with three laminæ, the median completely separated from the laterals by the normal angled groove, but not separated by a groove from the main portion of the tergal area. Sternal surface of opisthosoma strongly convex from side to side, forming an even transverse curve across the middle line from the margin of the laminæ of one side to that of the other, but without any lateral groove defining the laminæ. The posterior border of the sternal plates mostly strongly recurved, but the recurvature becoming progressively less and less marked anteriorly; the sternal plate corresponding to the second tergal plate nearly straight from side to side; two or three plates in front of this, the number being uncertain, the anterior being triangular and projecting between the coxæ of the legs of the last pair; its posterior border concave, probably marking the anterior rim of the genital orifice. The last plate on the ventral surface bearing the circular anal sclerite.

The coxæ of the five pairs of post-oral appendages radiate round the elongated sternal area of the prosoma, which is about twice as long as wide. Of the first pair of appendages or cheliceræ no details can be determined. Those of the second pair, the first post-oral appendages or palpi, are normally constructed and pediform, consisting of six segments; the remaining pairs are similar in form and segmentation and approximately similar in size, each consisting of the usual number of seven segments.

Type Species.—Trigonotarbus johnsoni, sp. nov.

Although in the structure of its carapace this genus presents greater resemblance to *Anthracomartus* than to *Eophrynus*, it approaches much nearer to the latter than to the former in the structure of the sternal plates of the opisthosoma, especially of those in the region of the generative orifice. It also resembles

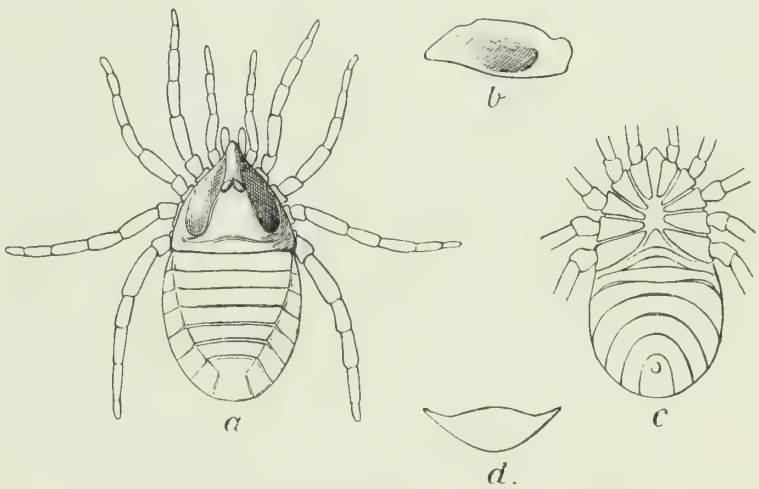


Fig. 38.—*Trigonotarbus johnsoni*, gen. et sp. n.; restoration from several specimens, about six times nat. size.—Coal Measures; Coseley, near Dudley. *a.*, dorsal surface with appendages; *b.*, lateral view of carapace, about eight times nat. size; *c.*, ventral surface; *d.*, transverse section of the opisthosoma to show the convexity of the ventral surface and the uptilted pleuræ.

Eophrynus in having the laminæ of this region undivided on the dorsal side, and not differentiated by a sulcus from the rest of the sternal plates on the sternal side of the opisthosoma. No doubt its nearest known ally is *Anthracosiro*, of which the sternal surface of the opisthosoma is unknown; but *Trigonotarbus* is certainly generically distinguishable by the shape of the carapace and of the laminæ of the opisthosoma, and by the absence of lateral constriction between the prosoma and opisthosoma.

Trigonotarbus johnsoni, sp. nov. Plate III, fig. 4; Text-figure 38.

Integument closely and tolerably uniformly granular. Carapace about as long as its own posterior width, and a little longer than the anterior six terga of the opisthosoma. Opisthosoma a little longer than wide; the terga subequal in length

mesially, the first not markedly longer than the rest; the first four straight, with parallel anterior and posterior borders; the fifth with its posterior border slightly recurved, the sixth with both anterior and posterior borders recurved or concave backwards. Palpi long and slender, excluding the coxa, longer than the carapace. First leg longer and stouter than the palpi, a little longer than the opisthosoma, and about one and a half times the length of the carapace, which is about equal to its trochanter, femur, patella, and half the tibia; the protarsus of the first leg apparently shorter than the tarsus. Fourth leg a little longer than the first, with its protarsus longer than its tarsus.

Measurements in mm.—Total length 4·8; length of carapace 2; of opisthosoma 2·8, width of latter about 2·5; length of palpus about 2·5; of first leg about 3, of fourth a little over 3.

Coseley, near Dudley.

Type, above described, in the Collection of Mr. Walter Egginton (No. 7).

In addition to the type there are many specimens in the Collections of Mr. Egginton, Mr. H. Johnson, and Mr. Madeley. They are all in clay ironstone nodules from the Dudley Coal Measures.

The largest specimens I have seen reach a length of about 6 mm.

Family Eophrynidæ, Karsch.

Eophrynidæ, Karsch, Scudder, Pocock, Fritsch.
Eophrynidæ + *Kreischeriidæ*, Haase.

Carapace with its median area elevated and marked with a deep, narrow longitudinal groove in its posterior half, and with one or two transverse sulci as well; furnished either anteriorly or mesially with an ocular tubercle bearing a pair of eyes. Behind the elevated portion there is a short depressed transverse portion abutting against the opisthosoma, and continuous laterally with the widely and horizontally extended lateral portion of the carapace, which is impressed with two sulci, the anterior of these being continuous with the sulcus of the median area that defines posteriorly the oculiferous area of the median portion. In front of the latter there is a longer or shorter apically narrow projecting portion, which apparently overhangs the cheliceræ. In typical members of this family (*Eophrynus*, *Kreischeria*) there appear to be at least two tergal plates in the opisthosoma in front of the seventh tergal plate from the end on the dorsal side, and the pleural laminæ, although large on all the seven normal and invariable terga, appear to be undivided. The anterior three sternal plates, at least in *Eophrynus*, are short, the first being triangular and wedged between the coxæ of the appendages of the last pair, the size and disposition of these plates being very similar to those of

Trigonotarbus amongst the Anthracosironidæ, and very different from those of the Anthracomartidæ.

The three British genera of this group may be distinguished as follows:

a. The posterior borders of the terga and of the pleural laminæ of the opisthosoma forming a transverse straight line, in no sense recurved . . . *Aphantomartus*.

a'. The posterior borders of the terga and of their pleural laminæ in the posterior half of the opisthosoma forming a markedly recurved line.

b. Carapace with median sulcus long and eyes far in advance of the middle, as in *Aphantomartus* . . . . . *Kreischeria*.

b'. Carapace with median sulcus short and eyes approximately central. *Eophrynus*.

In addition to the genera diagnosed above the following, not yet recorded from British deposits, have been referred to this family:

Stenotrogulus, Fritsch, based on *Eophrynus salmi*, Stur; *Cyclotrogulus*, Fritsch, based on *Eophrynus sturi*, Haase; *Petrovicia*, Fritsch, type *P. proditoria*, Fritsch; *Hemikreischeria*, Fritsch, based on *Kreischeria geinitzi*, Thevenin (= *thevenini*, Fritsch).[1]

The typical species of *Stenotrogulus*, *Cyclotrogulus*, and *Hemikreischeria* are certainly closely related to the species referred here to *Eophrynus* and *Kreischeria*, whatever be the value of the genera themselves. On the latter point, however, I can give no opinion since I have not seen the type specimens and am unable to place confidence in Fritsch's restorations. The same applies to *Petrovicia*.

Genus **EOPHRYNUS**, H. Woodward.

1837. *Curculioides*, W. Buckland, Bridgewater Treatise (2nd ed.), vol. ii, p. 76 (in part, *prestvicii*).
1871. *Eophrynus*, H. Woodward, Geol. Mag., vol. viii, p. 386, pl. xi.
1902–1903. *Eophrynus*, R. I. Pocock, Geol. Mag. [4], vol. ix, pp. 439—448 and 487—493; also vol. x, pp. 250—251.
1904. *Eophrynus*, A. Fritsch, Palæoz. Arachn., p. 46.

Type Species.—Eophrynus prestvici (Buckland).

Since no new material of this genus has come to hand since 1902—3, I have nothing to add to the description I gave of this genus in those years. The difficult morphological features then discussed remain as obscure as before.

[1] *Kreischeria geinitzi* was cited by Thevenin (Proc. Verb. Soc. d'Hist. Nat. d'Autun, vol. xv, p. 195, 1902), who ascribed the specific name to Brongniart. The species was re-named by Fritsch on the grounds that Brongniart gave no diagnosis or figure of the animal. I have therefore assigned the species to Thevenin, who figured and described the type specimen, from the Coal Measures of Valenciennes in France, as *Kreischeria geinitzi*.

Eophrynus prestvici (Buckland). Text-figure 39.

1837. *Curculioides prestvicii*, Buckland, Bridgewater Treatise (2nd ed.), vol. ii, p. 77, note, pl. xlvi, fig. 2.
1871. *Eophrynus prestvicii*, H. Woodward, Geol. Mag., vol. viii, pp. 386—388, pl. xi.
1902. *Eophrynus prestvicii*, R. I. Pocock, Geol. Mag. [4], vol. ix, pp. 440, fig. 1 on p. 490.
1904. *Eophrynus prestvicii*, A. Fritsch, Palæoz. Arachn., pp. 46—48, with fig.

The typical example of this species, discovered by Mr. W. Anstice and described

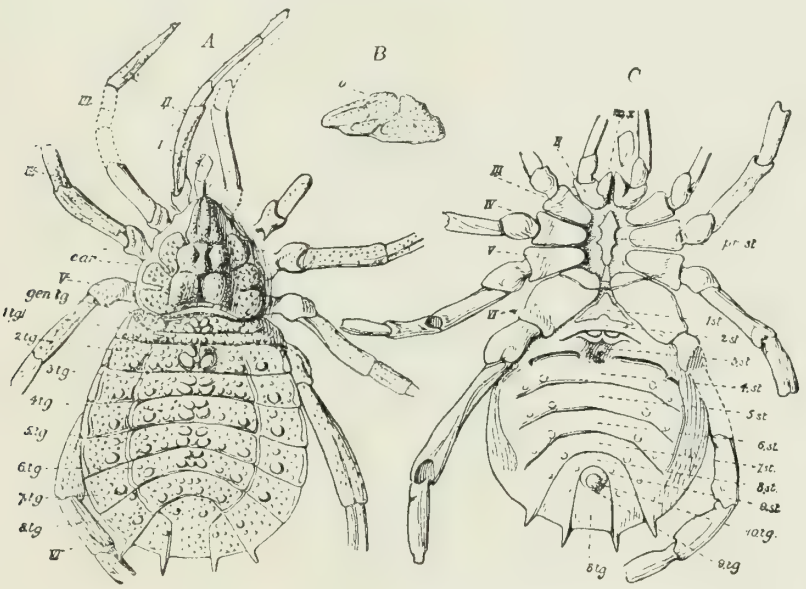


Fig. 39.—*Eophrynus prestvici* (Buckland); nearly twice nat. size.—Coal Measures; Coseley, near Dudley. *A*. Dorsal surface.—I to VI, appendages of the prosoma of the left side; *car.*, carapace; *gen. tg.* and *1 tg.*, first tergal plate of the opisthosoma apparently composed of the tergal elements of two somites; *2 tg.*, second tergal plate representing the first large tergal plate exposed in *Anthracomartus* and other genera; *3 tg. to 8 tg.*, third to the eighth tergal plates. *B*. Lateral view of carapace.—*o.*, eyes. *C*. Ventral surface.—II to VI, coxæ of postoral appendages; *mx.*, maxillary process of palpus; *pr. st.*, sternum of prosoma; *1 st.* to *9 st.*, sterna of first to ninth somites of the opisthosoma; *8 tg.*, lower side of the median lamina of the last tergal plate visible on the dorsal side; *9 tg.*, tergal plate of annuliform ninth somite; *10 tg.*, anal operculum or tergal plate of tenth somite. From Geol. Mag. [4], vol. ix, p. 490.

by Dean Buckland, came from Coalbrook Dale in Shropshire; the specimen described by Dr. Woodward and subsequent authors came from Dudley.

Genus **KREISCHERIA**, Geinitz.

1882. *Kreischeria*, H. B. Geinitz, Zeitschr. deutsch. geol. Ges., vol. xxxiv, p. 238, pl. xiv.
1890. *Kreischeria*, E. Haase, Zeitschr. deutsch. geol. Ges., vol. xlii, p. 642, pl. xxx, fig. 6.
1904. *Kreischeria*, A. Fritsch, Palæoz. Arachn., p. 50, fig. 63.

This genus, the type of which is *K. wiedei*, Geinitz, differs from *Eophrynus* at least in having the median sulcus of the carapace longer, wider, and expanding posteriorly, and the eyes well in advance of the middle of this plate. These

differences result from the greater development of the pre-ocular, and lesser development of the post-ocular region of the carapace in *Eophrynus* than in *Kreischeria*. In both these genera, as in *Aphantomartus*, it is quite clear that the eyes are situated upon that part of the median area of the carapace that corresponds to the anterior of the three pairs of lobes or segments of the lateral horizontally extended area.

The figures and description of the typical specimen of *K. wiedei*, published by Haase and Fritsch, are so irreconcileably discrepant that an accurate conception of the structure of the fossil is impossible. The species described below as new is certainly akin to that species, and I have decided on that account to refer it to the

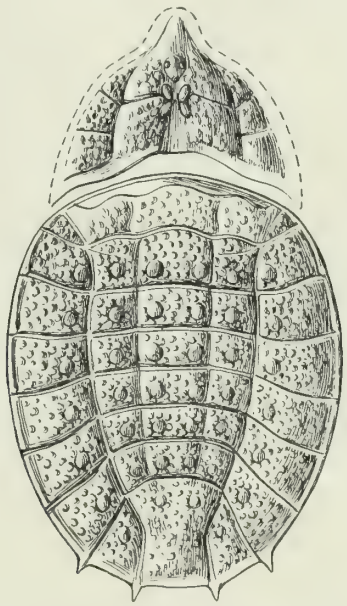


Fig. 40.—*Kreischeria verrucosa*, sp. n.; dorsal surface, about three times nat. size.—Coal Measures; South Wales. Museum of Geological Survey, London.

genus *Kreischeria*; but if the restoration of *K. wiedei* given by Fritsch is, as he claims, accurate, a new genus will probably have to be erected for *K. verrucosa*.

Kreischeria verrucosa, sp. nov. Plate III, fig. 5; Text-figure 40.

Carapace with four large and low suboval tubercles, lying behind the ocular tubercle and between it and the anterior end of the median sulcus, and set end to end in a rosette-shaped pattern; the anterior sulcus of the median area passing to the angle formed by the point of contact of the two tubercles on each side; a small median tubercle in the angle of the rosette just behind the ocular tubercle; the summit of the median elevated area of the carapace coarsely and rather closely tubercular; the sloping sides of the elevated area apparently smooth; the three segments of the horizontally extended area similarly tubercular, although the

inner portion of the median of the three laminæ is apparently smooth; all the tubercles irregular in size and more or less anastomosing; the central groove smooth. The entire dorsal surface of the opisthosoma covered with tubercles of varying size, which on the obverse show up as a number of pits separated by a network of ridges. Each of the posterior seven tergal plates, with exception of the seventh, divided more or less distinctly into five areas, a median elevated area, the pleural lamina on each side, and an intermediate area separated apparently by a joint from the pleural lamina, but only by a groove from the median more elevated area; the latter with two large tubercles, one on each side of the middle line, in addition to the smaller tubercles; the intermediate areas and the pleural laminæ each with one large tubercle, so that in all there are six rows of large tubercles on the dorsal surface. The structure of the seventh tergal plate is obscure; there are possibly two large tubercles on its median area, but there appear to be none on its pleural and median laminæ. The opisthosoma is evenly ovate in outline, being widely rounded in front, with its posterior extremity narrower and more truncated, and armed apparently as in *Eophrynus* with two pairs of short spiniform processes. The seventh tergal plate from the end, *i. e.* the first of the terga invariably shown in the Anthracomarti, is considerably longer than those that succeed it, but is otherwise similar to them, except that its intermediate area is marked in front with a groove defining a small lanceolate area. In front of this tergal plate there is a large plate with convex anterior border and marked with a transverse sinuous groove dividing it into an anterior shorter and a posterior longer portion, each of which may perhaps represent a tergal element; the posterior longer area has a distinct but small and triangular pleural lamina.

Measurements in mm.—Total length probably about 26; width of carapace about 10; length of opisthosoma 18, width 14·5.

Coal Measures of South Wales; Craigola Vein about 200 yards S.W. of Glyn-coch Farm.

Type and only known specimen (Nos. 25,020, 25,021) in the Museum of the Geological Survey, Jermyn Street.

Genus **APHANTOMARTUS**, nov.

Generic Characters.—Carapace with its median area longitudinally oblong and elevated; the elevated area divided with a transverse groove into two subequal portions, and marked with a deep median groove which passes forwards from the posterior border of the posterior portion on to the anterior portion, where it bifurcates on each side of the median ocular tubercle, which is situated near the anterior border of the anterior area. This tubercle bears a pair of eyes.

In front of the eye-bearing elevated portion there is a slightly lower anterior projection, about equal to it in width, the sides of which diverge posteriorly and are continuous with the lateral edge of the carapace; the summit of this projection is compressed to form a median crest with sinuous edges. The lateral portions of the carapace are depressed, somewhat widely extended beyond the elevated median area and marked with four grooves, the anterior of which is nearly longitudinal and lies alongside the anterior median projection; the following two are oblique, the first of them joining at its posterior end the transverse sulcus of the elevated area. The posterior groove is transverse and nearly in a line with the posterior border of the elevated area; it defines laterally the posterior part of the carapace, which is a short, wide area lying behind the median elevated portion; the posterior border of this, which abuts against the opisthosoma, is straight. The posterior angles of the carapace are rectangular, and the lateral margins slightly convex but becoming more strongly so anteriorly, where they curve inwards and forwards to meet the lateral margins of the anterior projecting portion; where the three posterior grooves reach the lateral margin they form angular projections making the lateral margin irregular in outline.

The opisthosoma shows only seven tergal plates; its anterior border where it abuts against the prosoma is straight; its sides are convex; at its widest it is as wide as the prosoma, and is narrowed and oval behind. The posterior border of all the tergal plates is straight and transverse, except of the last. Each plate is marked on each side by a sulcus separating a pair of lateral laminæ from the wider median portion of the tergum; these lateral plates are four-sided, with the exception of those of the seventh segment, which are triangular.

Type Species.—Aphantomartus areolatus, sp. nov.

Although obviously related to *Eophrynus* and *Kreischeria*, judging from the shape and segmentation of the carapace, this new genus decidedly differs from both not only in the structural details of that plate but also in those of the opisthosoma. For example, there is no sign of any segment or segments in front of the seventh from the end, and the posterior border of all the tergal plates is straight from side to side instead of presenting a strong recurvature at least in the posterior part of the body. The opisthosoma of *Aphantomartus*, indeed, differs very markedly from that of all the described genera of Eophrynidæ, especially at its posterior extremity. Some of it may possibly be buried in the matrix or missing, but the appearance of the fossil does not bear out this suggestion, the plausibility of which is further lessened by the occurrence of the same features in three specimens.

It is also possible that the peculiarities in the structure of the opisthosoma are due to immaturity, a possibility supported in a measure by the small size of the specimens as compared with the types of *Kreischeria verrucosa* and of *Eophrynus prestvici*. But although the possibility that the pleural laminæ increase in size

with growth must be borne in mind, there is as yet no evidence of the fact; and even were it known to be the case, the species now under discussion could not be assigned either to *Eophrynus* or *Kreischeria* on account of the structure of the carapace and the sculpturing of the opisthosoma.

Aphantomartus areolatus, sp. nov. Plate III, fig. 6; Text-figure 41.

Carapace wider than long, its median area with areolate sculpturing of large, low, contiguous tubercles, its lateral portions nearly smooth, slightly depressed. Terga of opisthosoma covered with large, low, mostly flattened tubercles, irregular in shape and varying in size; the first tergum with a large polygonal central tubercle encircled by smaller tubercles; between these and the pleural sulcus there

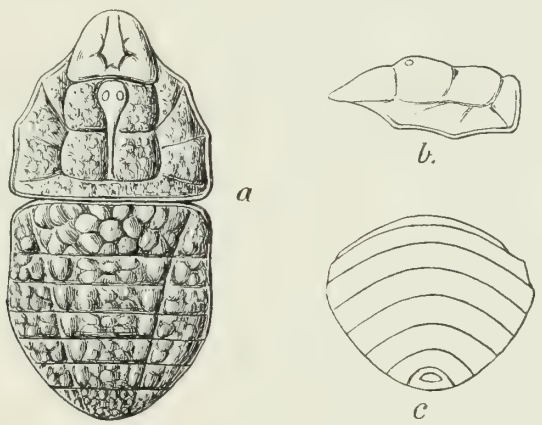


Fig. 41.—*Aphantomartus areolatus*, gen. et sp. n.; six times nat. size.—Coal Measures; South Wales. Museum of Geological Survey, London. *a.*, dorsal surface; *b.*, lateral view of carapace; *c.*, ventral surface of opisthosoma.

are several more tubercles, one of which on the postero-lateral angle of the median area of the tergum is a little more conspicuous than the rest, and subconical; the pleural plate also tubercular, one tubercle near its middle posteriorly being a little larger than the others. The succeeding terga very similarly sculptured, but with the large tubercle on the pleural plate and on the admedian side of the pleural sulcus still more conspicuous. These larger tubercles are not, however, present apparently on the tergum of the seventh segment.

Measurements in mm.—Total length about 9; length of carapace about 4, width 5; length of opisthosoma 5, width a little less.

Coal Measures of S. Wales: Mynyddislwyn vein; Gwernan level, three-quarters of a mile S.E. of Maes-y-cwmmer, and one-third of a mile E. of the Boot.

Type, above described, Nos. 25016 and 25017 in the Museum of the Geological Survey, Jermyn Street.

There is also a specimen (No. J. P. 565A) from the same locality and formation

in the Museum of the Geological Survey, which I regard as the posterior portion of the ventral surface of the opisthosoma of the same species. It is somewhat strongly convex from side to side, and like the ventral surface of *Eophrynus prestvicii* appears to be smooth, except for a few small symmetrically-arranged tubercles. The posterior portion of the fossil, however, is marked with a network of ridges, which I interpret as the pattern of the dorsal surface shown by the crushing of the sterna on the terga. The anal operculum is subterminal. In front of it there are seven concentrically curved plates, with the concavity of their posterior borders looking backwards; the first and second of these are much shorter than those that succeed them, the latter being subequal in length. The second plate is as wide as the third; the first, however, is much narrower, and tapers away to a point laterally. Total length and width about 5 mm.

A third specimen in the same collection (No. J. P. 402—403), also from the Mynyddislwyn vein in the Lebanus Colliery, by the roadside, two-thirds of a mile N. of Tredegar Junction, is represented by the posterior six segments of the opisthosoma, showing the characteristic sculpturing clearly on some of the plates. The total length and width are about 4·5 mm.

The species described by Scudder as *Anthracomartus pustulatus* (Proc. Amer. Acad. Arts Sci., vol. xx, p. 18, 1884; Mem. Bost. Soc. Nat. Hist., vol. iv, p. 452, pl. xl, figs. 5 and 8, 1890) shows many points of resemblance to this genus, and possibly belongs to it. In any case it cannot be referred to *Anthracomartus*. This specimen, from Mazon Creek, Illinois, appears to be either an impression of the dorsal surface or the underside of the dorsal exoskeleton, the pattern being a network of ridges circumscribing sunken polygonal "cells" or depressions. It may be noted that the posterior borders of the pleural plates and of the terga are in the same straight line, and that there is a long median groove on the carapace as in *Aphantomartus areolatus*. The pattern of the sculpturing, however, is different from that of the British species.

Order OPILIONES or ANTHRACOMARTI (?).

With considerable hesitation I refer to the Order Opiliones an Arachnid on a slab of shale from the Kiltoung Coal Seam, Ellismuir, sent to me by Mr. Robert Dunlop, who discovered it in 1888. It was in Dr. Peach's hands for some time, but was apparently never figured or described. The structural characters of the fossil are not sufficiently well preserved to make their exact interpretation possible. Since the surface is evidently closely granular I infer that the dorsal side is exposed, but owing to its being crushed, the outlines of the coxæ of at least the two posterior pairs of appendages are shown, and render obscure the form of the carapace in its

posterior region. From the shape of the fossil and the great length of the appendages I propose to identify it provisionally as :

Nemastomoides elaveris, Thevenin. Text-figure 42.

1902. *Nemastomoides elaveris,* A. Thevenin, Bull. Soc. Géol. France [4], vol. i, p. 609, pl. xiii, fig. 2.
1904. *Nemastomoides elaveris,* A. Fritsch, Palæoz. Arachn., p. 29, fig. 34.

The carapace appears to be broad in front and to have the antero-lateral angles subrectangular. Its anterior portion in front of the coxæ of the legs of the third pair is higher in the middle than at the sides, and has a central longitudinal groove

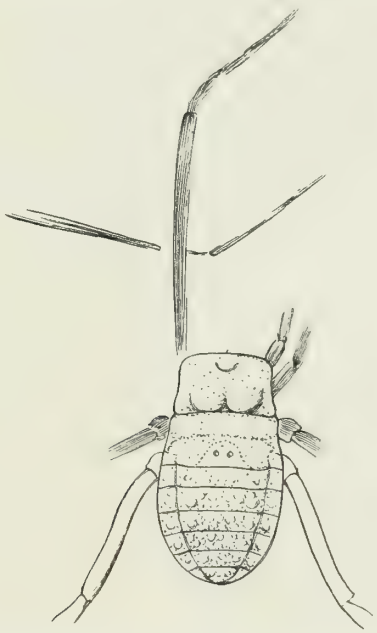


Fig. 42.—? *Nemastomoides elaveris,* Thevenin ; suggested restoration of the dorsal surface, five times nat. size.—Coal Measures ; Ellismuir. R. Dunlop Collection.

posteriorly. The coxæ of the third and fourth pairs of legs do not appear to meet in the middle line ; those of the third pair diverge transversely in the same straight line ; those of the fourth pair, about equal to them in size, diverge obliquely backwards, and between them there appears to be a triangular plate which must probably be regarded as the first sternal plate of the opisthosoma seen vaguely through the median area of the first tergal plate of that region. It is marked with a pair of distinct tubercles, belonging probably to the sculpturing of the dorsal surface. Behind this plate the outline and segmentation of the opisthosoma are clearly seen. Its shape is semi-elliptical, being broad in front, gradually narrowed and rounded behind. There are six distinct plates with their anterior and posterior borders subparallel, each consisting of a median area and a pair of uptilted pleural laminæ, as in typical Anthracomarti ; the pleural laminæ

of the last are quite small, and there is no evidence that there was a median unpaired extension of the last beyond the anus, which is not shown. The width of the opisthosoma is about equal to its length from the posterior end to the apex of the triangular intercoxal plate, the length from the latter point to the anterior end of the prosoma being a little longer than the length of the last four segments of the opisthosoma. The sculpturing of the opisthosoma consists of close-set granulation broken up into larger, indefinitely tubercular areas.

Leg of the fourth pair with its trochanter, femur, and patella almost as long as the entire body; leg of first pair extraordinarily long and slender, the femur alone exceeding the entire length of the body.

Measurements in mm.—Total length 6; length of the last six segments of the opisthosoma 3, width of the latter region 3·5; width of anterior portion of prosoma 3, its length to the anterior groove 1·7; femur of fourth leg about 4, of first leg about 7.

The specimen above described came from the Kiltoung Coal Seam, Ellismuir, Baillieston, in Scotland, and is in the Collection of Mr. Robert Dunlop.

The type of *N. elaveris* was from the Coal Measures at Commentry, in France.

PLATE I.

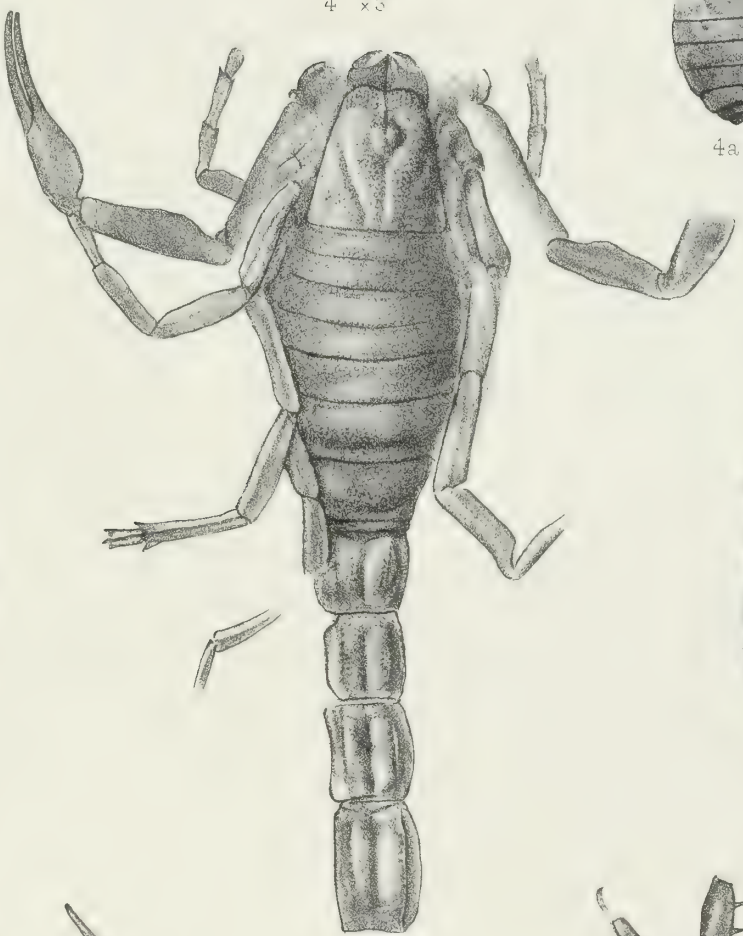
Fig.		Page.
1.	*Anthracoscorpio dunlopi*, sp. nov.; dorsal view of type and only known specimen, nat. size.—Upper Coal Measures, Drumgray, near Airdrie, Lanarkshire. R. Dunlop Collection. The outlines of the carapace and of the anterior terga of the opisthosoma are more clearly defined than in the original.	21.
2.	*Anthracoscorpio buthiformis*, sp. nov.; sternal surface of prosoma and tergal plates of opisthosoma, three times nat. size.—Coal Measures; Coseley, near Dudley. B. M. no. I. 1555.	27.
2 *a*.	Ditto; dorsal view, three times nat. size.—Ibid. W. Egginton Collection, no. 43. The anterior border of the carapace is much more clearly shown than in the original.	27.
3.	*Geralinura britannica*, sp. nov.; dorsal view of type specimen, three times nat. size.—Ibid. W. Egginton Collection, no. 51. The outlines of the segments of the chela are more clearly shown than in the original.	29.
4.	*Græophonus anglicus*, sp. nov.; dorsal view, three times nat. size.—Ibid. W. Egginton Collection, no. 40.	32.
4 *a*.	Ditto; dorsal view of type specimen, two and a half times nat size.—Ibid. W. Egginton Collection, no. 1.	32.
4 *b*.	Ditto; sternal surface of prosoma and tergal plates of opisthosoma, two and a half times nat. size.—Ibid. W. Egginton Collection, no. 20.	33.
4 *c*.	Ditto; same surfaces as in fig. 4 *b*, three times nat. size.—Ibid. W. Egginton Collection, no. 2.	32.
4 *d*.	Ditto; dorsal view of carapace, four times nat. size.—Coal Measures, near Neath, South Wales. Museum of Geological Survey, Jermyn Street, London.	33.

Pocock, British Carboniferous Arachnida. Pl I.

3. ×3

4 ×3

4a ×2½



1. *nat. size.*

2a ×4

2. ×3

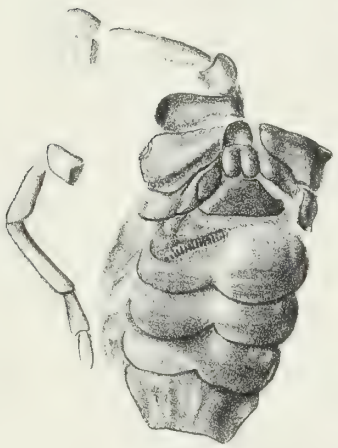
4c ×2

4d ×4

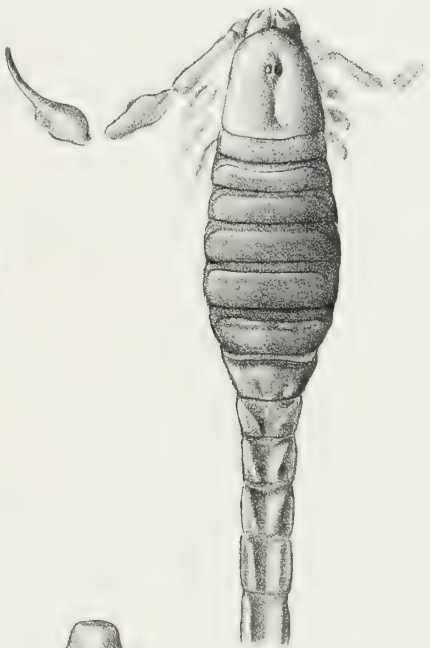
4b. ×2½

PLATE II.

Fig.		Page.
1.	*Anthracoscorpio buthiformis*, sp. nov.; dorsal view of type specimen, four times nat. size.—Coal Measures; Sparth, near Rochdale. W. A. Parker Collection.	24.
2.	*Eobuthus holti*, sp. nov.; ventral view, nat. size.—Ibid. F. Holt Collection.	14.
2 *a*.	Ditto (?); ventral view of posterior end of opisthosoma, nat. size.—Coal Measures; Shipley, near Nottingham. L. Moysey Collection.	15.
2 *b*.	Ditto (?); dorsal view of same specimen, showing tergal plates crowded together and overlapping, nat. size.	15.
3.	*Geralinura britannica*, sp. nov.; dorsal view, three times nat. size.—Ibid. L. Moysey Collection.	30.
4.	*Eocteniza silvicola*, gen. et sp. nov.; dorsal view of type specimen, three times nat. size.—Coal Measures; Coseley, near Dudley. W. Egginton Collection.	34.
5.	*Plesiosiro madeleyi*, gen. et sp. nov.; dorsal view, five times nat. size.—Ibid. W. Egginton Collection, no. 4.	44.
6.	*Poliochera alticeps*, sp. nov.; dorsal view of type specimen, seven times nat. size.—Ibid. W. Egginton Collection, no. 6.	40.
7.	*Curculioides ansticii*, Buckland; dorsal view, four times nat. size.—Ibid. W. Egginton Collection, no. 33.	39.
7 *a*.	Ditto; ventral view of same specimen (exact shape of coxæ doubtful), four times nat. size.	39.

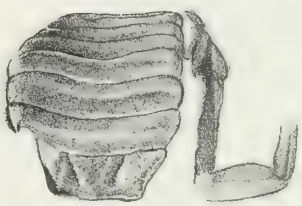


2. *nat.size*



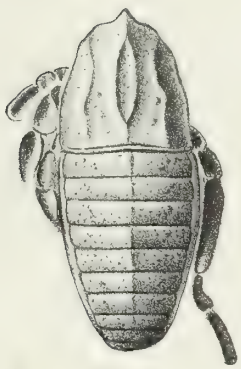
1. ×4

2a. *nat.size*



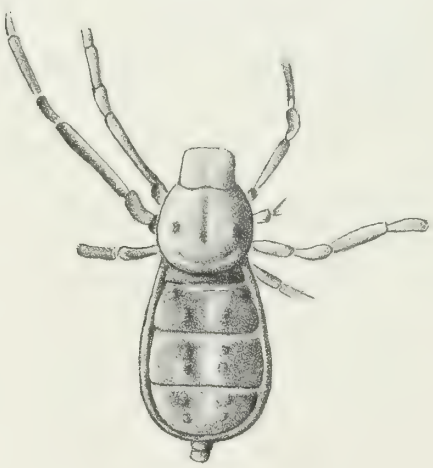
2b. *nat.size*

4. ×3



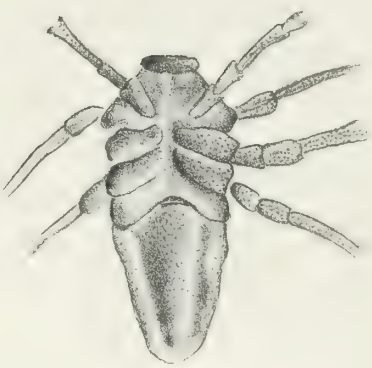
5. ×5

3. ×3



6. ×2

7. ×4

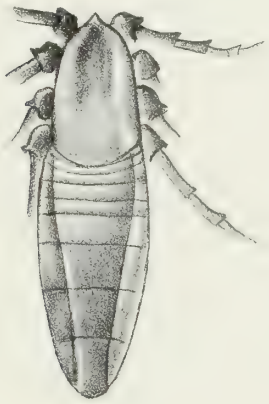


7a. ×4

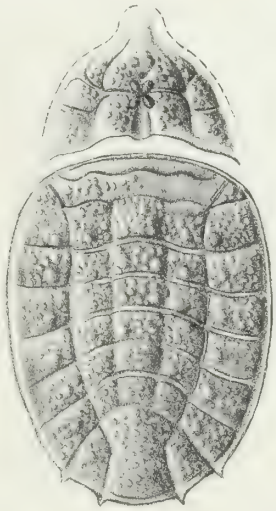
PLATE III.

Fig.		Page.
1.	*Geraphrynus torpedo*, sp. nov.; dorsal surface of type specimen from below, four times nat. size.—Coal Measures; Coseley, near Dudley. W. Egginton Collection, no. 10.	54.
1 *a*.	Ditto; ventral surface of same specimen from above, four times nat. size.	54.
2.	*Geraphrynus angulatus*, sp. nov.; dorsal surface of type specimen from below, four times nat. size.—Ibid. Wheelton Hind Collection.	49.
2 *a*.	Ditto; ventral surface of same specimen from above, four times nat. size.	49.
3.	*Anthracomartus hindi*, sp. nov.; dorsal surface of type specimen from below, twice nat. size.—Ibid. Museum of Geological Survey, Jermyn Street, no. 12148.	64.
4.	*Trigonotarbus johnsoni*, gen. et sp. nov.; dorsal surface of type specimen, seven times nat. size.—Ibid. W. Egginton Collection, no. 7.	74.
4 *a*.	Ditto; ventral surface of same specimen, seven times nat. size.	74.
5.	*Kreischeria verrucosa*, sp. nov.; dorsal view of type specimen, two and a half times nat. size.—Coal Measures; South Wales. Museum of Geological Survey, Jermyn Street, nos. 25,020—21.	78.
6.	*Aphantomartus areolatus*, gen. et sp. nov.; dorsal view of type specimen, five times nat. size.—Coal Measures; South Wales. Museum of Geological Survey, Jermyn Street, nos. 25,016—17.	81.

Pocock, British Carboniferous Arachnida. Pl. III.



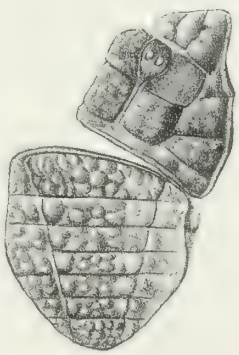
1. ×4



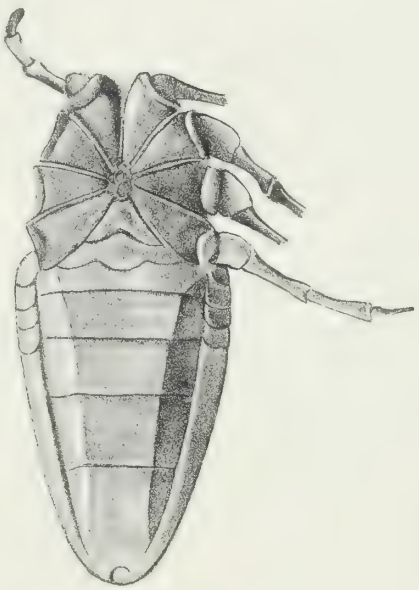
5. ×2½

1a. ×4

2. ×4



6. ×5



2a. ×4

4. ×7

3 ×2

4a. ×7

G. M. Woodward. del. et lith.

West, Newman imp.

Palæontographical Society, 1910.

A MONOGRAPH

OF

BRITISH GRAPTOLITES.

BY

GERTRUDE L. ELLES, Sc.D.,

LATE GEOFFREY FELLOW, NEWNHAM COLLEGE, CAMBRIDGE;

AND

ETHEL M. R. WOOD, D.Sc.

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PART VIII.

Pages 359—414; Plates XXXVI—XLI.

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Family **MONOGRAPTIDÆ,** *Lapworth.*

1873. *Monograptidæ*, Lapworth, Geol. Mag., vol. x, table 1, p. 555.

Unilateral Graptoloidea, polypary simple or compound, straight or curved. Thecæ varied in form, growing upward in a single linear series along the line of the virgula.

In the forms belonging to this family the first theca is budded from a variable point along the length of the sicula and grows at once upward and outward; all the succeeding thecæ follow the same direction.

This type of development, as we have already pointed out (p. 347), has been anticipated in the Dimorphograptidæ; but in that family the polypary is uniserial in the proximal portion and biserial in the distal portion, whereas in the Monograptidæ it is uniserial throughout.

The family of the Monograptidæ as originally founded, was regarded as embracing three genera: *Monograptus*, Geinitz, restricted, *Rastrites*, Barrande, and *Cyrtograptus*, Carruthers. *Cyrtograptus* included all the branching species; *Rastrites* those unbranching forms in which the thecæ had the appearance of being isolate; and *Monograptus* the remaining unbranching and more typical forms of the family.

The branching nature of the polypary in *Cyrtograptus* is perhaps sufficiently distinctive to entitle the group so named to generic rank; but it is doubtful if the peculiarities of the thecæ in the forms united under *Rastrites* are of greater significance than those characteristic of the various sub-groups in *Monograptus* itself, and *Rastrites* is here regarded as a sub-genus.

Genus **MONOGRAPTUS**, *Geinitz, restricted.*

1852. *Monograptus*, Geinitz, Die Graptolithen, p. 32.

Polypary simple.

Thecæ cylindrical, conical, or somewhat flattened tubes; in contact, overlapping, or becoming more or less isolate; walls straight or curved; apertural margins variable in form, plain or ornamented.

The polypary in *Monograptus* presents many variations in its general features, apart from considerations of length and breadth. In several species the polypary is straight (*Monog. jaculum*), but in the majority it is distinctly curved. The curvature may be (1) *ventral*, the polypary being bent forward in the direction of the ventral margin and bearing the thecæ upon the inner side of the curve (*Monog. bohemicus*); or (2) *dorsal*, the polypary being curved backward and bearing the

thecæ upon the outer side (*Monog. cyphus*) ; or in a few cases (3) *dorsi-ventral*, the curvature changing sign along the length of the polypary (*Monog. flexilis*).

In some species the curvature is *slight* throughout (*Monog. flexuosus*). As a general rule, however, the curvature is distinctly *pronounced*, but in varying degrees, the complete polypary becoming arc-shaped, sickle-shaped, hook-shaped, or whip-shaped in general form, the earlier portion of the polypary being almost invariably more sharply curved than the mature portion. In a few species the curvature is *excessive* and continuous, the polypary being coiled into a plane spiral (*Monog. convolutus*), or even into a conical helix (*Monog. turriculatus*).

The thecæ in *Monograptus* differ chiefly in (1) general form, (2) amount of overlap or isolation, (3) form of the apertural margin. As regards general form they may vary from a simple parallel-sided tube to a tube with decided sigmoid curvature, or from a tube with ogee-curvature to a short truncated cone, these variations being often closely connected with the amount of overlap or isolation. There appear to be thecæ showing every condition from those which overlap for the greater part of their length (*Monog. leptotheca*) through those with partial isolation (*i.e.* of the apertural region only) (*Monog. Sedgwickii*) into those in which the isolation is more complete and the overlap is reduced to a minimum (*Monog. convolutus*). One of the characteristic features of the Monograptidæ is this tendency, in many of its species, to isolation of the thecæ, the various stages of which are well displayed within the genus *Monograptus* itself.

There is, however, another tendency which affects the form and direction of the apertural margin and also of the apertural region of the theca. In many species the theca has a simple and normal apertural margin, but in others it shows a certain amount of extroversion and retroversion, originating a minute tag (or rostel) to the outer angle (*Monog. revolutus*). In others the apertural region of the theca itself becomes extroverted and retroverted (*Monog. priodon*, etc.), and eventually, a definite coiled-up lobe is formed (*Monog. lobiferus*). The tendency to isolation may sometimes act alone (*Rastrites peregrinus*), but it is more generally accompanied by the allied tendency to lobation.

The sicula in *Monograptus* varies much in size, and it is generally minute. In *Monog. acinaces* and *Monog. gregarius*, however, it attains the greatest extent known among the Graptoloidea, the sicula in these species having a length of fully 4—5 mm.

The virgula is, as a rule, inconspicuous, but the dorsal impression or groove marking its position is often well seen in polyparies which are preserved in full relief. It is occasionally prolonged beyond the distal extremity of the polypary (*Monog. varians*).

As respects the classificatory grouping of the species of the *Monograpti*, the forms and relations of the thecæ afford us, as hitherto, the most satisfactory criteria. But here an apparent difficulty confronts us. In some of the *Monograpti*

the thecæ are of the same type (*uniform*) throughout the whole length of the polypary; in others two types at least occur (*bi-form*), one in the earlier portion and another in the later or mature portion. In the families of the Dichograptidæ, Dicranograptidæ and Dimorphograptidæ also the earlier thecæ occasionally differ from those subsequently developed in the later or more mature stages of the growth of the polypary, but the latter have been always considered to be the more characteristic and distinctive. There can be little doubt, therefore, that in the matter of the classification of the species in the *Monograpti* the characters of the thecæ in the mature portion of the polypary should similarly take systematic precedence of those of the earlier portion. On this basis the *Monograpti* fall into seven main groups, which can be further subdivided.

Group I.—*Monograpti* in which the mature thecæ are simple, straight, overlapping tubes with approximately parallel walls and even apertural margins.

Type *Monog. cyphus.*

Group II.—*Monograpti* in which the mature thecæ are tubes with flowing sigmoid curvature and oblique apertural margins.

Type *Monog. Sandersoni.*

Group III.—*Monograpti* in which the mature thecæ are short tubes with abrupt sigmoid curvature and some torsion of the thecal axes, so that the apertural margins show occasionally within distinct excavations in the ventral margin.

Type *Monog. vomerinus.*

Group IV.—*Monograpti* in which the mature thecæ are tubes with the apertural region more or less isolate and retroverted.

Type *Monog. priodon.*

Group V.—*Monograpti* in which the mature thecæ are tubes with the whole apertural region coiled into a definite lobe.

Type *Monog. lobiferus.*

Group VI.—*Monograpti* in which the mature thecæ are triangular or conical in form with reflexed apertural margins.

Type *Monog. convolutus.*

Group VII.—*Monograpti* in which the mature thecæ are more or less linear and isolate with reflexed terminations.

Type *Rastrites peregrinus.*

Group I.

Monograpti in which the mature thecæ are simple, straight, overlapping tubes with approximately parallel walls and even apertural margins.

The Graptolites included in this group may be further divided into sections and sub-sections according to whether the thecæ are uniform or biform, and according to the kind of curvature of the polypary.

A. With *uniform* thecæ—

1. With curved polypary.

(*a*) The polypary has *dorsal* curvature. Type *Monograptus cyphus*. *M. acinaces*, *M. gregarius*.

(*b*) The polypary has *ventral* curvature. Type *Monograptus bohemicus*. *M. concinnus*.

(*c*) The polypary has *dorsi-ventral* curvature. Type *Monograptus Nilssoni*.

2. With straight polypary. Type *Monograptus leptotheca*.

M. regularis, *M. jaculum*, *M. variabilis*, *M. nudus*, *M. dubius*, *M. vulgaris*, var. *curtus*, *M. tumescens*, var. *minor*, *M. comis*, *M.* cf. *gotlandicus*, *M.* cf. *ultimus*.

B. With *bi-form* thecæ—

1. With curved polypary.

(*a*) The polypary has *dorsal* curvature. Type *Monograptus revolutus*.

M. revolutus var. *austerus*, var. *præcursor*, *M. difformis*, *M. argenteus*, var. *cygneus*, *M. limatulus*.

2. With approximately straight polypary. Type *Monograptus colonus*.

M. colonus var. *ludensis*, var. *compactus*, *M. varians*, var. *pumilus*, *M. Roemeri*, *M. chimæra*, var. *Salweyi*, var. *semi-spinosus*, *M. leintwardinensis*, var. *incipiens*.

I. A. 1. (*a*): *Monograpti* in which the thecæ are uniform, and the polypary has dorsal curvature.

Monograptus cyphus, Lapworth. Plate XXXVI, figs. 1 *a*—*e*.

1876. *Monograptus cyphus*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 352, pl. xii, figs. 3 *a* and 3 *c*.

Polypary several cm. in length, slightly arcuate distally with either involute or broadly recurved proximal portion, widening persistently from a long and conspicuous sicula to a maximum diameter of 1·5 mm. Thecæ ten to nine in 10 mm., simple tubes with even apertural margins, overlapping one-third of their length near the sicula, and as much as two-thirds in the more mature portions of the polypary.

Description.—The form of the polypary, with the broad sweeping curve of the early portion, is highly characteristic, but the amount of curvature varies somewhat in different individuals, being rather more abrupt in some than in others.

The sicula alone forms the proximal termination of the polypary; it is fairly robust and very long, measuring fully 4 mm. in length; its apex lies about midway

between the apertures of th. 1 and th. 2, and the first theca (th. 1) arises about one-third of the way along its length.

Figs. 236 *a—c.—Monograptus cyphus*, Lapw.

a. Proximal end, showing sicula. Rheidol Gorge, Cardiganshire; Rheidol Group. Coll. O. T. Jones.
b. Ditto, in full relief. Same locality.
c. Proximal end, showing abrupt curvature. Garple Linn, Moffat; Lower Birkhill Shales. Coll. Geol. Survey of Scotland.

All the thecæ are simple, straight-walled, narrow tubes, with normal apertural margins which may appear slightly concave or even convex after compression; in their general characters they resemble those previously described as characteristic of the Dichograptidæ; they have a length of 3 mm., and are about six times as long as wide. The amount of overlap increases steadily from one-third of their length near the sicula to one-half in the broadly recurved portion, and eventually to two-thirds of the total length in the mature portion of the polypary, where a horizontal line drawn through an aperture would cut three different thecæ. The apertural margins in the mature portion lie obliquely with respect to the general direction of the polypary, but are in every case normal to the theca itself. In specimens preserved in relief the overlap of the thecæ is clearly seen, but occasionally, as the result of compression, the thecæ appear somewhat like those characteristic of *Climacograptus*, and the overlap is then apparently less (Pl. XXXVI, fig. 1 *a*).

Figs. 236 *d* and *e.—Monograptus cyphus*, Lapw.

d. Thecæ near the proximal end of the polypary. Dobb's Linn; Lower Birkhill Shales. Coll. Lapworth.
e. Distal thecæ of same specimen.

Affinities.—Monog. cyphus resembles in its general form several other members of the group; it may, however, be readily distinguished by the breadth of the distal portion of the polypary, and the simple character and extensive overlap of its thecæ. Distal fragments may resemble fragments of *Monog. leptotheca*, but the polypary of *M. cyphus* is more curved, and the overlap of the thecæ less for a given breadth of stipe.

Horizon and Localities.—Llandovery (Birkhill Shales), zone of *M. cyphus*.

S. Scotland: Waterfall, Long Linn, Dobb's Linn, Moffat; Garple Linn, Moffat;

Lockerbie; Duffkinnell. *Lake District:* Skelgill. *Wales:* Llanystwmdwy, near Criccieth; Rhayader; Pont Erwyd, etc. *Ireland:* Donaghadee; Mill Sluice below Slate Quarry, Pomeroy.

Associates, etc.—*Monog. cyphus* is an abundant and characteristic fossil in the Birkhill Shales of S. Scotland and their equivalents elsewhere, lying immediately below the zone of *Monog. gregarius* (sub-zone *M. fimbriatus*). It commonly occurs associated with *Monog. revolutus* and var. *austerus*, *M. Sandersoni*, *M. atavus*, *Dimorphog. physophora*, *Climacog. rectangularis*, and other forms.

Collectors.—Lapworth, Jones, Fearnsides, and the Authors.

Monograptus acinaces, Törnquist. Plate XXXVI, figs. 2 *a—e.*

1899. *Monograptus acinaces*, Törnquist, Monograptidæ of Scanian *Rastrites* Beds, Lunds Univ. Årsskrift, vol. xxxv, pt. 2, no. 1, p. 5, pl. i, figs. 7, 8.

1909. *Monograptus rheidolensis*, Jones, Quart. Journ. Geol. Soc., vol. lxv, p. 535, figs. 19 *a—c.*

Polypary several cm. in length, approximately straight distally but arcuate in proximal portion, very slender at first, but increasing in width till a maximum of 2 mm. is attained. Thecæ six to eleven in 10 mm., those of the proximal portion very long slender tubes overlapping about one-half their length, those of the distal portion expanding somewhat in the apertural region and overlapping two-thirds their length.

Figs. 237 *a – d.*—*Monograptus acinaces*, Törnq.

a. Proximal end, showing sicula. Figured as *M. rheidolensis*, Quart. Journ. Geol. Soc., vol. lxv, fig. 19 *b*. Rheidol Gorge, Cardiganshire; Rheidol Group (zone of *M. rheidolensis*). Geol. Survey of England and Wales, Jermyn St. (23705).

b. Thecæ in median portion of the polypary. Enlargement of part of Pl. XXXVI, fig. 2 *a*.

c. Distal thecæ in relief. Rheidol Gorge; Rheidol Group. Coll. O. T. Jones.

d. Distal thecæ in relief. Figured Quart. Journ. Geol. Soc., vol. lxv, fig. 19 *d*. Geol. Survey of England and Wales (23704).

Description.—The arcuate proximal portion of the polypary with its very long slender thecæ is highly characteristic of this species; distally the curvature becomes less and may eventually disappear altogether. The polypary is of great but unknown length, probably reaching 30 cm. at least. Small fragments in which the maximum width is not attained are those of commonest occurrence.

The sicula is very long and slender, measuring 5 mm. in length and reaching to half-way between the apertures of th. 1 and th. 2; it alone forms the termination of the polypary, since th. 1 arises some distance above the aperture of the sicula.

The whole proximal end of the polypary is extremely slender, and the thecæ are very long (4—5 mm.), growing approximately parallel with the general

direction of the polypary; they overlap about one-half their length, and are about twenty times as long as broad; the apertural margins are even and approximately horizontal. In the more distal portion of the polypary the thecæ are about the same length, but are only ten times as long as broad, have a higher inclination, and overlap for fully two-thirds of their length; they expand somewhat in the apertural region and as a result the walls show a tendency to slight curvature; the apertural margins are even and everted. The thecæ are so slender even in the distal portion that a horizontal line drawn across the polypary at any point would cut three different thecæ at least.

Remarks.—Törnquist, in his original description of this species, stated that he was unacquainted with the distal extremity of the polypary. The British form here described agrees so closely with Törnquist's species as regards the proximal end that it is practically certain that the two are identical; the features of the thecæ of the distal portion of the polypary are, however, so striking and distinct from those of the proximal portion that the British specimens were described by Jones as a new species—*Monog. rheidolensis.*

Affinities.—In the length of the thecæ, their slender nature and amount of overlap, *Monog. acinaces* approaches *M. leptotheca*, with which it seems to have been formerly confused; the distal thecæ of *M. leptotheca*, however, show no such characteristic expansion in their apertural regions, and are even more slender than those of *M. acinaces.*

Horizon and Localities.—Llandovery (Birkhill Shales), zone of *M. cyphus.*

C. Wales: Rheidol Gorge. *S. Scotland:* Waterfall, Long Linn, Dobb's Linn, etc.

Associates, etc.—*Monog. acinaces* appears to be a fairly abundant fossil in the zone of *M. cyphus*, especially in the Pont Erwyd district, where Jones records it in a band below that in which *M. cyphus* is most abundant. It has also been found in S. Scotland in the zone of *M. cyphus.*

Collections.—Jones, Lapworth, and Geological Survey of England and Wales.

Monograptus gregarius, Lapworth. Plate XXXVI, figs. 3 *a—d.*

1851. *Graptolites Nilssoni*, Harkness, Quart. Journ. Geol. Soc., vol. vii, p. 61, pl. i, figs. 7 *a—d.*
1868. *Graptolites Nilssoni* (pars), Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 537, pl. xx, fig. 19.
1876. *Monograptus gregarius*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 317, pl. x, figs. 12 *a—c.*
1876. *Monograptus gregarius*, Lapworth, Cat. West. Scott. Foss., pl. 1, fig. 7.
1877. *Monograptus gregarius*, Lapworth, Proc. Belfast Nat. Field Club, p. 131, pl. v, fig. 4.
1892. *Monograptus gregarius*, Törnquist, Siljansomr. Graptol., Acta Univ. Lund., vol. xxviii, p. 8.
1897. *Pristiograptus gregarius*, Frech, Leth. Geogn., pt. i, vol. i, pl. i, figs. 3—5, p. 660, fig. 215.
1899. *Monograptus gregarius*, Törnquist, Monograptidæ of Scanian *Rastrites* Beds, Lunds Univ. Årssk., vol. xxxv, pt. 2, no. 1, p. 4, pl. i, figs. 1—6.

Polypary short, arcuate, with an average length of 3 cm. and uniform breadth of about ·75 mm. Sicula very conspicuous and of great length. Thecæ ten in 10 mm., simple tubes with even apertural margins lying perpendicularly to the general trend of the polypary, overlap increasing from mere contact to one-third of thecal length.

Description.—The gregarious habit of this species is highly characteristic, slabs of rock being covered with its small stiffly curved polyparies.

The proximal end appears unusually robust on account of the extent and size of the sicula, which measures fully 5 mm. in length, and which reaches up to the level of the aperture of th. 5, whence it gradually merges into the virgula; since th. 1 arises a little distance above the aperture of the sicula, the sicula together with five thecæ form the proximal portion of the polypary.

FIGS. 238 *a* and *b*.—*Monograptus gregarius*, Lapw.

a. Proximal end, showing sicula. Dobb's Linn; Mid. Birkhill Shales. Coll. Lapworth.
b. Specimen in relief, showing sicula. Ibid.?

The thecæ show a distinct tendency to expand in the direction of the aperture.

Affinities.—The stiffly curved polypary and the robust character of the proximal end, together with the disposition of the relatively gigantic sicula, should serve readily to separate this species from any other *Monograptus*. Distal fragments, however, have sometimes a superficial resemblance to those of *M. intermedius* when badly preserved, though the thecæ of the latter species are different in form.

Horizon and Localities.—Llandovery (Birkhill Shales), zone of *M. gregarius*.

S. Scotland: Dobb's Linn; Belcraig Burn; Garple Linn; Frenchland Burn; etc. *N. Ireland:* Coalpit Bay, Donaghadee: *Wales:* Twymyn River, near Llanbrynmair; Rhayader; etc.; Pont Erwyd; etc. *Lake District:* Skelgill; Browgill; Stile End.

Associates, etc.—*Monog. gregarius* is one of the commonest fossils in the Llandovery wherever the graptolitic facies is developed; it occurs in swarms as a general rule, and is often associated with *Monog. fimbriatus, M. communis, M. triangulatus, Rastrites approximatus, Glyptog. sinuatus, G. tamariscus, Climacog. Törnquisti* and other forms.

Collections.—Geological Survey of Scotland, Sedgwick Museum, British Museum (Natural History), Lapworth, Fearnsides, Jones, and the Authors, etc.

I. A. 1. (*b*): *Monograpti* in which the thecæ are uniform and the polypary shows ventral curvature.

Monograptus bohemicus (Barrande). Plate XXXVI, figs. 4 *a—d*.

1850. *Graptolithus bohemicus*, Barrande, Graptolites de Bohême, p. 40, pl. i, figs. 15—18.
1851. *Graptolithus bohemicus*, Suess, Ueber Böhmische Graptolithen, pp. 110—111, pl. viii, figs. 6 *a—e*.
1851. ? *Graptolithus Barrandei*, Scharenberg, Ueber Graptolithen, etc., Inaug. Dissert. (Breslau), p. 15, pl. i, figs. 5—5 *a*.
1852. *Monograptus bohemicus*, Geinitz, Die Graptolithen . . . der Grauwackenformation in Sachsen, p. 36, pl. ii, fig. 41.
1869. *Graptolithus bohemicus*, Heidenhain, Zeitschr. d. deutsch. geol. Gesellsch., vol. xxi, p. 149, pl. i, figs. 4 *a—c*.
1881. *Graptolithus scalaris*, Quenstedt, Petrefactenkunde Deutschl., vol. vi, pl. cl, fig. 44.
1883. *Monograptus bohemicus*, Tullberg, Skånes Graptoliter, pl. iii, figs. 3—5.
1884 *Monograptus bohemicus*, J. D. La Touche, Handbook to the Geology of Shropshire, p. 77, pl. xviii, fig. 573.
1889. *Pristiograptus bohemicus*, Jaekel, Zeitschr. d. deutsch. geol. Gesellsch., vol. xli, p. 672, pl. xxviii, figs. 3—6.
1890. *Monograptus bohemicus*, Geinitz, Die Graptolithen d. k. Min. Mus. in Dresden, p. 14, pl. A, fig. 10.
1897. *Pristiograptus bohemicus*, Frech, Leth. Geogn., vol. i, pt. iii, p. 644.
1900. *Monograptus bohemicus*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 483, text-fig. 25, pl. xxv, figs. 27 A and 27 B.

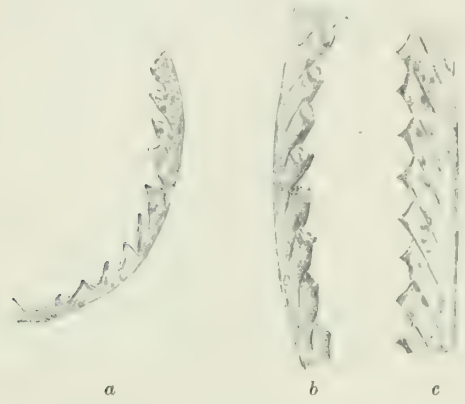
Polypary several cm. in length, straight distally, with broad concave sweep in the proximal portion, widening steadily till a maximum breadth of 2 mm. is attained. Thecæ eleven to nine in 10 mm., simple short tubes with a maximum length of about 2 mm., two to three times as long as wide, overlapping one-third to one-half their length; average inclination 30—35°; apertural margins wide.

Description.—The broad sweep of the polypary in the proximal region is highly characteristic of the species, and in small individuals the whole polypary appears to share in the curvature, the straight distal portion being only seen in long specimens.

The sicula is usually conspicuous; it has a length of about 1 mm. and its great width in the apertural region gives a distinctive character to the proximal end as a whole; the virgella is usually stout.

The thecæ are short and broad tubes quite simple in character, though in the concave portion of the polypary the breadth of the apertures often induces impression of the ventral wall of the theca lying next above, giving a characteristic appearance to the polypary after compression.

Figs. 239 *a—c.*—*Monograptus bohemicus* (Barr.).



a. Proximal end, showing sicula. Figured Quart. Journ. Geol. Soc., vol. lvi, p. 484, fig. 25 *b*. Elton-Ludlow Road; Lower Ludlow Shales. Coll. Wood.

b. More distal thecæ in relief. Figured Quart. Journ. Geol. Soc., vol. lvi, p. 484, fig. 25 *a*. River Irfon, Builth; Lower Ludlow Shales. Coll. Wood

c. Thecæ of extreme distal portion. Enlargement of part of Plate XXXVI, fig. 4 *d*.

Affinities.—*Monog. bohemicus* is a perfectly distinct and well-marked species which should not be confounded with any other *Monograptus*.

Horizon and Localities.—Lower Ludlow Shales (zone of *M. Nilssoni*). *Lake District:* Helm Knot, Dent, etc. *Wales:* Deeside Slab Quarries, Moel Ferna. *Welsh Borders:* Aberedw Hill, Builth; River Irfon, Builth; Vicarage Road, Builth, etc. *Ludlow District:* Elton Lane; Elton-Evenhay Lane; Elton-Ludlow Road, etc.

Associates, etc.—*Monog. bohemicus* is a fairly common fossil in the Lower Ludlow Shales of many localities, but especially in the zone of *M. Nilssoni*. It occurs in this zone associated with *Monog. Nilssoni*, *M. colonus*, *M. varians*, and *Gothog. spinosus;* and with *M. scanicus*, *M. chimaera*, and *M. tumescens* at higher horizons.

Collections.—Sedgwick Museum, Lapworth, and the Authors, etc.

Monograptus concinnus, Lapworth. Plate XXXVI, figs. 5 *a—e*.

1876. *Monograptus concinnus*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 320, pl. xi, figs. 1 *a—e*.

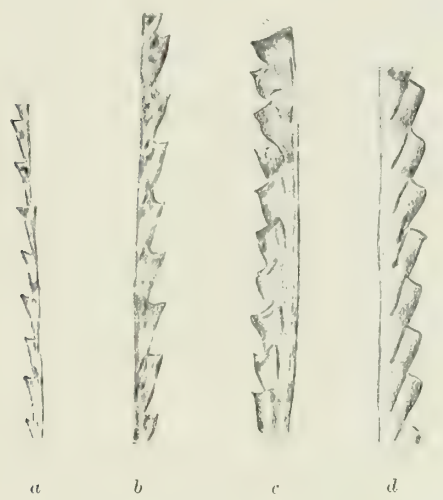
Polypary several cm. in length, with incurved proximal portion and slight ventral curvature distally, gradually widening from a slender proximal end to an average breadth of 1 mm. Thecæ twelve to ten in 10 mm., simple short tubes expanding in the apertural region, overlapping one-third to one-half their length, and with wide, even and everted apertural margins.

Description.—The polypary appears to be always more or less curved, but the curvature is perhaps most pronounced proximally; it widens gradually from a very slender proximal termination, but maintains a uniform breadth for a considerable distance in the distal portion.

The thecæ are short, broad tubes, about 1·5 mm. in length in the maturer part of the polypary, and in many respects resemble those of *M. nudus*, the appearance of an excavation being heightened by the ventral curvature of the polypary.

Affinities.—*Monog. concinnus* may always be distinguished by the form of the polypary with its pronounced curvature, which contrasts effectively with the straight and rigid form of *M. nudus*. Fragments of *M. concinnus*, however,

Figs. 240 *a—d.*—*Monograptus concinnus*, Lapw.



a. Thecæ of proximal portion. Part of specimen on same slab as Pl. XXXVI, fig. 5 *b*.
b. Ibid.
c. Distal thecæ. Enlargement of part of Pl. XXXVI, fig. 5 *e*.
d. Distal thecæ in relief, probably referable to this species. Rheidol Gorge, 420 yds. E.S.E. of Bryn-chwith Farm house, Pont Erwyd, Cardiganshire. Geol. Survey of England and Wales.

strongly resemble those of *M. Nilssoni*, but may be distinguished by the more closely set thecæ and by the different curvature of the proximal portion of the polypary.

Horizon and Localities.—Llandovery (Birkhill Shales), zones of *M. gregarius* to *M. Sedgwickii*. *S. Scotland:* Dobb's Linn; Belcraig Burn; Garple Linn, etc. *Wales:* Pont Erwyd (various localities); Pary's Mountain, Anglesea. *Lake District:* Skelgill, etc.

Associates, etc.—Monog. concinnus appears first in the *M. gregarius* zone, but is commonest in the zones of *M. convolutus* and *M. Sedgwickii*, where it is associated with *Monog. convolutus*, *M. tenuis*, *M. Sedgwickii*, *Cephalog. cometa*, *Glyptog. serratus* var. *barbatus*, and other forms.

Collections.—Geological Surveys of Scotland, and of England and Wales, Jones, Greenly, Lapworth, and the Authors.

I. A. 1. (*c*): *Monograpti* in which the thecæ are uniform and the polypary has dorsi-ventral curvature.

Monograptus Nilssoni (Barrande). Plate XXXVII, figs. 1 *a—c*.

1850. *Graptolithus Nilssoni*, Barrande, Grapt. de Bohême, p. 51, pl. ii, fig. 16.
1852. *Monograptus Nilssoni*, Geinitz, Die Graptolithen . . . der Grauwackenformation in Sachsen, p. 35, pl. ii, figs. 17—20, 24, 25, 28—32 (?).
1869. *Monograptus Nilssoni*, Heidenhain, Zeitschr. d. deutsch. geol. Gesellsch., vol. xxi, p. 147, pl. i, fig. 2.
1876. *Monograptus Nilssoni*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 315, pl. x, figs. 7 *a—c*.
1876. *Monograptus Nilssoni*, Haupt, Die Fauna des Graptolithengesteines, p. 21, pl. iv, fig. 3 (?).
1878. *Monograptus Nilssoni*, Kayser, Die ältesten Devon-Ablagerungen des Harzes, p. 217, pl. xxxi, fig. 12 (fig. 25 ?).
1883. *Monograptus Nilssoni*, Tullberg, Skånes Graptoliter, pl. i, figs. 31, 32.
1884. *Monograptus Nilssoni*, J. D. La Touche, Handbook to the Geology of Shropshire, p. 78, pl. xviii, fig. 576.
1885 ?. *Monograptus scanicus*, Roemer, *non* Tullberg, Lethæa Erratica, pl. ix, figs. 13 *a*, *b*.
1889. *Pristiograptus Nilssoni*, Jaekel, Zeitschr. d. deutsch. geol. Gesellsch., vol. xli, p. 673, pl. xxviii, fig. 7.
1890. *Monograptus Nilssoni*, Geinitz, Die Graptolithen d. k. Min. Mus. in Dresden, p. 13, pl. A, fig. 7 (in part), *non* fig. 8.

1897. *Linograptus Nilssoni*, Frech, Leth. Geogn., vol. i, pt. iii, p. 662, fig. 218.

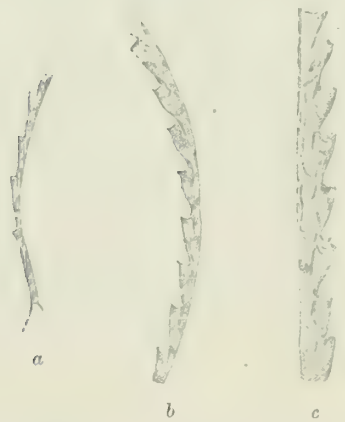
1899. *Monograptus Nilssoni*, Perner, Études sur les Graptolites de Bohême, pt. iii, sect. *b*, p. 7, pl. xvii, figs. 1, 2, 7.

1900. *Monograptus Nilssoni*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 482, text-fig. 24, pl. xxv, figs. 28A, 28B.

Polypary several cm. in length, straight distally, but with graceful double curvature in the proximal portion; slender, never exceeding 1 mm. in breadth. Thecæ eight to nine in 10 mm.; simple tubes with slight tendency to sigmoid curvature, about 2 mm. in length, four to five times as long as wide, overlapping about one-third their length, inclination low; apertural margins normal, those of straight distal portion usually at right angles to the direction of the polypary.

Description.—The form of the polypary with its straight distal portion, concave middle portion, and convex proximal termination, is highly characteristic. It is extremely slender at the proximal end, measuring only ·2 mm., and then widens gradually and persistently till the maximum breadth of 1 mm. is attained.

FIGS. 241 *a*—*c*.—*Monograptus Nilssoni* (Barr.).



a. Proximal end, showing sicula. Figured Quart. Journ. Geol. Soc., vol lvi, p. 482, fig. 24*a*. Montgomery Road, near Welshpool; Lower Ludlow Shales. Coll. Wood.
b. Thecæ of proximal portion of the polypary. Enlargement of part of Pl. XXXVII, fig. 1 *a*.
c. Distal thecæ. Enlargement of part of Plate XXXVII, fig. 1 *c*.

The sicula is small, but distinct; it has a length of about 1·5 mm., and the first theca arises near its apex, so that the apertural portion of the sicula alone forms the termination of the polypary.

The thecæ are simple straight tubes overlapping the merest fraction of their length in the convex proximal portion of the polypary; but with the beginning of the concave portion, a slight curvature makes its appearance in the walls, and this is even better seen in the straight distal part. The apertural margins are even and normal, but while those of the concave portion usually lie somewhat obliquely to the general direction of the polypary, those of the straight distal part are approximately at right angles, though not invariably so.

Affinities.—The nearest relation of *Monog. Nilssoni* is undoubtedly *Cyrtog. Carruthersi* of the Upper Wenlock Beds, fragments of which are indistinguishable from similar fragments of *M. Nilssoni* when both are similarly preserved, the only distinguishing feature being the presence of branches in the *Cyrtograptus* form.

Horizon and Localities.—Lower Ludlow Shales (zone of *M. Nilssoni*).

Lake District: Moughton Whetstone Hole, Crummackdale. *Welsh Borders:* Montgomery Road; River Irfon near Builth; Vicarage Road, Builth; Old Dingle

Mill, Long Mountain, etc. *N. Wales:* Deeside Slab Quarries, Moel Ferna. *Ludlow District:* Elton Lane; Elton-Ludlow Road; Adferton.

Associates, etc.—Monog. Nilssoni is a very abundant fossil in the Lower Ludlow Shales, fragments of the distal straight portion, from 5—7 cm. in length, being of frequent occurrence at some localities; specimens showing the graceful double curvature of the proximal region are much rarer. It usually occurs associated with *Monog. colonus* and var. *compactus*, *M. bohemicus*, *M. varians* and var. *pumilus*, *M. Roemeri*, *M. dubius*, *M. uncinatus* var. *orbatus*, and var. *micropoma*.

Collections.—Sedgwick Museum, Lapworth, the Authors, etc.

I. A. 2: *Monograpti* in which the thecæ are uniform and the polypary is straight.

Monograptus leptotheca, Lapworth. Plate XXXVII, figs. 2 *a—d*.

1876. *Monograptus leptotheca,* Lapworth, Geol. Mag., dec. ii, vol. iii, p. 352, pl. xii, figs. 4 *a –e*.
1876. *Monograptus leptotheca,* Lapworth, Cat. West. Scott. Foss., pl. i, fig. 14.
1877. *Monograptus leptotheca,* Lapworth, Proc. Belfast Nat Field Club, p. 130, pl. v, fig. 22.
1882. *Monograptus leptotheca,* Tullberg, Graps. descr. by Hisinger, Bihang K. Vet. Akad. Handl., vol. vi, p. 12, pl ii, figs. 8—12.
1899. *Monograptus leptotheca,* Törnquist, Monograptidæ of Scanian *Rastrites* Beds, Lunds Univ. Årssk., vol. xxxv, pt. 2, no. 1, p. 5.

Polypary of very great but unknown length, approximately straight and stiff, but with slight curvature near proximal end; widening gradually and persistently till the maximum breadth of 3 mm. is attained. Thecæ eight to ten in 10 mm., extremely long slender tubes, overlap considerable even in initial portion and reaching a maximum of fully three-quarters of the thecal length; apertural margins even, approximately horizontal.

Description.—Though the proximal portion is not well known, it is clear that the polypary itself must have been remarkably long, for fragmentary specimens exceeding 10 cm. in length are known in which the breadth is uniform throughout, while others 8 or 9 cm. in length are also known in which the maximum breadth is not attained and in which the thecæ are only about half as long as those of the more distal portions. In most specimens, indeed, the maximum breadth is never seen; these commonly show a width of about 2 mm. only.

The mature thecæ have a length of fully 8 mm., their walls tend to show slight curvature, and there is a slight expansion in the apertural region; so extremely slender are they that on an average a horizontal line in any distal fragment would cut through four or five thecæ. Their overlap is always considerable, and increases throughout the length of the polypary until the maximum breadth is attained, after which it appears to be constant.

Affinities.—The very long slender thecæ with their great overlap are highly characteristic of this species, the only forms approaching it in this respect being *M. acinaces* and *M. regularis*. In *M. acinaces*, however, the distal thecæ are more trumpet-shaped and the overlap is not so great, while in *M. regularis* the overlap is also less and the proximal end of the polypary is stiff and straight like the distal termination.

Figs. 242 *a*—*c*.—*Monograptus leptotheca*, Lapworth.

a *b* *c*

a. Thecæ of the proximal portion of the polypary, part preserved as a cast, part in relief. Enlargement of part of Pl. XXXVII, fig. 2 *b*.
b. More distal part of same specimen.
c. Distal thecæ, preserved as a cast, figured Lapworth, Geol. Mag., 1876, pl. xii, fig. 4 *e*. Dobb's Linn; Birkhill Shales. Coll. Lapworth.

Horizon and Localities.—Llandovery (Birkhill Shales), zones of *M. gregarius* to *M. Sedgwickii*.

S. Scotland: Dobb's Linn; Belcraig Burn; Frenchland Burn, etc. *C. Wales:* Rhayader; Rheidol Gorge; River Twymyn. *N. Wales:* Pary's Mountain, Anglesea; Llanystwmdwy. *Lake District:* Skelgill; W. side Long Sleddale; Stile End; Whinny Gill, Cross How Beck.

Associates, etc.—*Monog. leptotheca* seems to make its first appearance in the zone of *M. gregarius* about the horizon of the *M. argenteus* band, in which it is very common. It is also fairly abundant in the zone of *M. convolutus* and survives into the zone of *M. Sedgwickii*. It is commonly associated with *Monog. argenteus*, var. *cygneus*, *M. gregarius* and *M. millepeda* at the lower horizon, with *M. convolutus*, *M. involutus* and *M. harpago* in the *M. convolutus* zone, and with *M. tenuis* and *M. Sedgwickii* in the zone of *M. Sedgwickii*.

Collections.—Geological Surveys of England and Wales, and Scotland, Sedgwick Museum, Jones, Greenly, Lapworth, and the Authors.

Monograptus regularis, Törnquist. Plate XXXVII, figs. 3 *a*—*d*.

1899. *Monograptus regularis*, Törnquist, Monograptidæ of Scanian *Rastrites* Beds, Lunds Univ. Arssk., vol. xxxv, pt. 2, no. 1, p. 7, pl. i, figs. 9—14.

Polypary several cm. in length, straight and approximately rigid throughout, widening persistently from an initial breadth of about ·3 mm. till the maximum width of 1·5 mm. is attained. Thecæ twelve to eight in 10 mm., simple tubes overlapping but slightly in the proximal portion, but overlap increasing to two-thirds of total length distally; apertural margins wide, even, slightly everted.

Description.—The polypary is often very long, and the increase in breadth in the proximal portion is so gradual as to be scarcely perceptible.

The sicula is small, not exceeding ·7 mm. in length, and barely reaches to the level of the aperture of th. 1 which arises close to its base.

Figs. 243 *a—c.*—*Monograptus regularis*, Törnquist.

a. Proximal portion of the polypary, showing sicula. East side of old quarry, N.E. of Fagwr-fawr Farm, 2 miles E.N.E. of Pont Erwyd, Cardiganshire. Coll. Geol. Survey of England and Wales.
b. More distal thecæ. Enlargement of part of Pl. XXXVII, fig. 3 *a*.
c. Distal thecæ. Llanystwmdwy, near Criccieth; Upper Llandovery beds. Coll. Fearnsides.

The thecæ of the proximal portion overlap very slightly and have their apertural margins approximately perpendicular to the general trend of the polypary; the overlap, however, increases steadily until in the distal portion the thecæ overlap fully two-thirds of their length; they narrow somewhat towards their apertural margins, which are slightly everted. The length of a mature theca is about 3·5 mm.

Affinities.—In the general form of the polypary *Monog. regularis* comes fairly near to *M. jaculum*, especially as regards the character of the proximal end; but in *M. jaculum* the distal thecæ never show so large an amount of overlap. As regards the characters of the distal thecæ *M. regularis* approaches *M. leptotheca* and might be confounded with it, but the overlap is never so great, nor are the thecæ so slender as in that species.

Horizon and Localities.—Llandovery (Birkhill Shales), zone of *M. convolutus*.

Wales: Rheidol Gorge; River Twymyn, near Llanbrynmair; Pary's Mt., Anglesea, etc. *S. Scotland:* Dobb's Linn; Belcraig. *Ireland:* Near Limehill, Pomeroy.

Associates, etc.—*Monog. regularis* seems to occur most abundantly in the zone of *M. convolutus*, associated with *M. convolutus*, *M. involutus*, *M. harpago*, *Cephalog. cometa*, and other forms. It is possible that it ranges even higher, but this is uncertain.

Collections.—Sedgwick Museum, Geological Surveys of England and Wales, and Scotland, Jones, Greenly, Fearnsides, and the Authors.

Monograptus jaculum (Lapworth). Plate XXXVII, figs. 4 *a—d*.

1876. *Monograptus Hisingeri*, var. *jaculum*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 351, pl. xii, figs. 2 *a—d*; and Cat. West. Scott. Foss., pl. i, fig. 13.

1877. *Monograptus Hisingeri*, var. *jaculum*, Lapworth, Proc. Belfast Nat. Field Club, p. 130, pl. v, fig. 20.

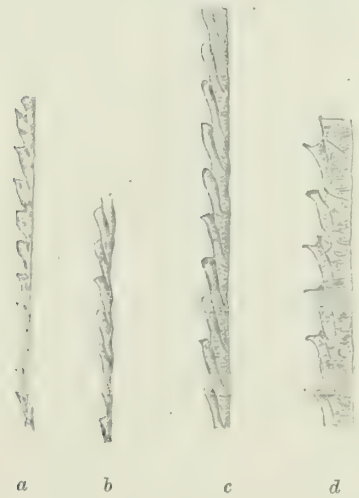
1899. *Monograptus jaculum*, Törnquist, Lunds Univ. Arssk., vol. xxxv, pt. 2, no. 1, p. 7, pl. i, figs. 15—17.

Polypary often of great length, straight or with very slight curvature, slender

at origin but widening persistently to a maximum breadth of about 1·5 mm. Thecæ fourteen to nine in 10 mm., simple tubes, overlap insignificant in the proximal portion, but reaching a maximum of about one-half the total length distally; apertural margins wide and even, generally more or less horizontal.

Description.—The polypary may, and often does, attain a great length, but specimens with a length of only 3 or 4 cm. are of commonest occurrence.

Figs. 244 *a—d.*—*Monograptus jaculum* (Lapworth).



a *b* *c* *d*

a. Proximal end, showing part of sicula. Morroch Bay, nr. Port Patrick; Birkhill Shales. Coll. Geol. Survey of Scotland.
b. Proximal portion in relief. R. Yarrow; Upper Birkhill Shales (Band of *Monograptus Halli*). Coll. Lapworth.
c. Distal thecæ in relief. Ibid.
d. More distal thecæ, slightly compressed. Dobb's Linn, Upper Birkhill Shales. Coll. Lapworth.

The sicula is small, not exceeding ·7 mm. in length, but reaching fully to the level of the aperture of th. 1.

The thecæ in the proximal portion are very small and closely set, but become more distant towards the distal extremity of the polypary. The apertural margins tend to be more or less horizontal, *i. e.* perpendicular to the general trend of the polypary, and occupy about one-third of the total breadth of it in profile view. The mature theca has a length of about 2·5 mm.

Affinities.—*Monog. jaculum* approaches *M. regularis* in the characters of the proximal end and the initial thecæ, except that these are more closely set; in the distal portion, however, both the length of the thecæ and their overlap are much less in the former species.

Horizon and Localities.—Llandovery (Birkhill Shales), zones of *M. gregarius* to *M. Sedgwickii.*

S. Scotland: Dobb's Linn; Belcraig Burn; Garple Linn; Lockerbie, etc. *C. Wales:* Rheidol Gorge, etc. *N. Wales:* Llanystwmdwy; Conway, etc. *Ireland:* Coalpit Bay, Donaghadee; Limehill, Co. Tyrone; Little River, Pomeroy, Co. Tyrone, etc. *Lake District:* Skelgill; Long Sleddale; Tributary of Hall Gill, etc.

Associates, etc.—*Monog. jaculum* is a very common fossil in the Upper Birkhill Shales of Moffat and their equivalents elsewhere. It occurs associated with *Monog. gregarius*, *M. leptotheca*, *M. Clingani*, *M. communis*, *M. convolutus*, *M. harpago*, *M. involutus*, *M. Sedgwickii*, *Cephalog. cometa*, and many other forms.

Collections.—Sedgwick Museum, Geological Surveys of England and Wales, and of Scotland, Jones, Lapworth, and the Authors.

Monograptus variabilis (Perner). Plate XXXVII, figs. 5 *a*, *b*.

1897. *Monograptus jaculum*, var. *variabilis*, Perner, Études sur les Grapt. de Bohême, pt. iii, p. 12, pl. xiii, figs. 10, 11—15.

Polypary some cm. in length, straight or with slight tendency to curvature, increasing in breadth from an initial width of ·4 mm. to a maximum of rather less than 1 mm. Thecæ twelve to eight in 10 mm., simple tubes slightly expanded in the apertural region, with slight overlap; apertural margins even, horizontal, or slightly introverted.

Description.—The polypary may attain a length of 5 cm. or more, but never exceeds 1 mm. in width and is usually rather less.

Figs. 245 *a—c.*—*Monograptus variabilis* (Perner).

a. Proximal end, showing sicula. Enlargement of part of Pl. XXXVII, fig. 5 *a*.
b. More distal portion of same specimen.
c. Distal thecæ in low relief. Enlargement of part of Pl. XXXVII, fig. 5 *b*.

The sicula is small, measuring only 1·5 mm. in length, but reaching well beyond the level of the aperture of th. 1.

The apertural margins of the earliest two thecæ appear to be slightly everted, but thereafter they are horizontal or even slightly introverted; the overlap may reach one-third of the total thecal length as a maximum.

Affinities.—The polypary presents some features in common with both *M. nudus* and distal fragments of *M. Nilssoni*. From *M. nudus* its diminutive breadth should be sufficient to separate it; and from *M. Nilssoni* it differs in the form of the polypary, and also in the shape of the theca which shows a greater tendency to curvature of the thecal walls and introversion of the apertural margin, approaching in these respects the form characteristic of the group of *M. Sandersoni*.

Horizon and Localities.—Gala-Tarannon Beds (zone of *M. crispus*).

N. Wales: Conway.

Associates, etc.—*Monog. variabilis* occurs in the zone of *M. crispus* associated with *Monog. Marri* and other forms.

Collection.—Elles.

Monograptus nudus (Lapworth). Plate XXXVII, figs. 6 *a—e*.

1876. *Monograptus Hisingeri*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 350, pl. xii, figs. 1 *a—c*.
1880. *Monograptus Hisingeri* var. *nudus*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 156, pl. iv, figs. 7 *a—c*.

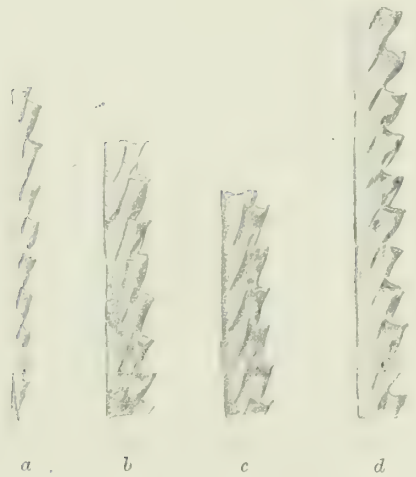
Polypary 3—5 cm. in length, straight or with very slight curvature, widening fairly rapidly to a maximum breadth of 2 mm. Thecæ nine to ten in 10 mm., simple broad tubes, somewhat sacculate in the apertural region, overlapping one-half their length, and with even, wide, apertural margins.

Description.—The polypary of *Monog. nudus* is usually straight and rigid, resembling that of *M. jaculum*, but it does not exceed 5 cm. in length.

The sicula is fully 1 mm. in length, and extends up to the aperture of th. 1, which originates near its base.

The thecæ increase in length from 1·5 mm. proximally to 2 mm. distally, and the overlap increases from one-third to one-half. They are simple sacculate tubes, very broad in proportion to their length, with their free ventral margin somewhat impressed, producing a slight excavation. The average inclination of the thecæ is high.

FIGS. 246 *a—d.*—*Monograptus nudus* (Lapworth).



a *b* *c* *d*

a. Proximal end, showing sicula, in low relief. Enlargement of part of Pl. XXXVII, fig. 6 *b*.
b. Distal thecæ, in relief, showing ventral excavation. Enlargement of part of Pl. XXXVII, fig. 6 *d*.
c. Distal thecæ preserved as a cast. Ibid.
d. Distal thecæ, compressed, showing their short and broad character. Enlargement of part of Pl. XXXVII, fig. 6 *a*.

Affinities.—In the form of the polypary *Monog. nudus* approaches *M. jaculum*, but differs in having shorter and broader thecæ with a ventral excavation. As respects the thecæ *Monog. nudus* approaches *M. concinnus*, but differs in having a straight polypary.

Horizon and Localities. — Llandovery — Tarannon.

S. Scotland: Dobb's Linn; Belcraig Burn; Grieston Quarry; Broadmeadows, Glendearg, etc. *Wales:* Llanystwmdwy, near Criccieth; Conway; Tarannon River; Llanbrynmair Railway section, etc.; Pont Erwyd District.

Associates, etc.—*Monog. nudus* is a characteristic Gala-Tarannon species; it is, however, occasionally found in the highest Llandovery beds. It occurs with *Monog. Sedgwickii* and *M. tenuis* at the Llandovery horizon, and with *M. turriculatus*, *M. exiguus*, *M. discus*, *M. Marri*, *M. griestonensis*, and other forms in the Gala-Tarannon beds. It is fairly abundant.

Collections.—Geological Survey of England and Wales, Lapworth and the Authors.

Monograptus dubius (Suess). Plate XXXVII, figs. 7 *a—d.*

1850. *Graptolithus colonus*, Barrande, Grapt. de Bohême, p. 43, pl. ii, fig. 5.
1851. *Graptolithus dubius*, Suess, Ueber Böhmische Graptolithen, Haidinger's Abhandl., vol. iv, pt. iv, p. 115, and pl. ix, figs. 5 *a*, 5 *b*.
1876. *Monograptus dubius*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 506, pl. xx, fig. 10.
1880. *Monograptus serra*, Hopkinson MS., Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, pl. iv, figs. 6 *c*, *d*.
1883. *Monograptus dubius*, Tullberg, Skånes Graptoliter, pt. ii, Sv. Geol. Undersökn, Ser. C, no. 55, p. 29, pl. i, figs. 28, 29, pl. ii, figs. 20, 21.

1890. *Monograptus dubius*, Holm, Gotlands Graptoliter, Bihang till k. Svensk. Vet. Akad. Handl., vol. xvi, pt. iv, no. 7, p. 16, pl. i, figs. 18—26.

1893. *Monograptus dubius*, Wiman, Bull. Geol. Inst. Upsala, vol. i, no. 2, p. 2, pl. vii.

1900. *Monograptus dubius*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 454, pl. xxv, figs. 1 A, 1 B, text-fig. 9.

Polypary with a maximum length of 10 cm., straight distally, but with slight ventral curvature in the proximal portion, widening gradually till maximum breadth of 2 mm. is attained. Thecæ eleven to eight in 10 mm., fairly long and wide tubes two or three times as long as wide, overlapping from less than one-half to rather more than one-half their length; average inclination 30°—35°.

Description.—The polypary varies considerably in extent; at some horizons in the Wenlock Shales it rarely exceeds 4 cm. in length, and seldom attains the maximum breadth; whilst in the Lower Ludlow Shales it is frequently 10 cm. long; in all other respects, however, the examples from both formations agree exactly. The slight ventral curvature of the proximal portion in the neighbourhood of the conspicuous sicula is highly characteristic; it rarely involves more than six thecæ.

FIGS. 247 *a* and *b*.—*Monograptus dubius* (Suess.).

a

b

a. Proximal end, showing sicula. Enlargement of part of Pl. XXXVII, fig. 7 *a*.

b. Distal thecæ, part in low relief. Enlargement of part of Pl. XXXVII, fig. 7 *b*.

The sicula has a length of 1·7 mm. and is about four and a half times as long as wide; its apex reaches approximately to the level of the second thecal aperture.

The proportions of the distal thecæ are fairly constant; the apertural margins are even but frequently somewhat thickened to form a sort of flange, which gives rise to a blunt denticle after compression. The average length of the mature thecæ is 3 mm.

Affinities.—*Monog. dubius* somewhat resembles in its general characters both *M. vulgaris* and *M. tumescens*, but should be readily distinguished from the former by the proximal ventral curvature, and from the latter by the shorter broader thecæ. It has often been confused with *M. colonus*, but the two are easily separated owing to the absence in *M. dubius* of any retroversion of the thecæ such as is characteristic of the proximal end of *M. colonus*.

Horizon and Localities.—Wenlock—Ludlow (zone of *M. riccartonensis* to zone of *M. scanicus*).

S. Scotland: Riccarton; Hindhope, etc. *Lake District:* Moughton; Whetstone Hole; below Rother Bridge, etc. *Welsh Borders:* Walcot Quarry, Chirbury; Coed

Mawr Quarry, near Builth; Builth Road; Dulas Brook, near Builth; Irfon River, near Builth; Llwynrhedith Quarry, Long Mountain; Glyn Brook, Long Mountain, etc. *Ludlow District:* Elton Lane; Stormer Hall; Elton-Ludlow Road, etc.

Associates, etc.—Monog. dubius is a common fossil in almost all localities where Wenlock and Lower Ludlow Shales are found. It seems to make its first appearance in Britain in the zone of *M. riccartonensis*, and quickly becomes so abundant that it is one of the commonest fossils in all the remaining four Wenlock Shale zones; it is also frequent in the basal zones of the Lower Ludlow Shales, but dies out in the zone of *Monog. scanicus*. It may therefore occur associated with the typical fossils of all these zones.

Collections.—Sedgwick Museum, British Museum (Natural History), Hopkinson, Lapworth, the Authors, etc.

Monograptus vulgaris, Wood. Plate XXXVII, figs. 10 *a—e*.

1900. *Monograptus vulgaris*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 455, pl. xxv, fig. 2, and text-fig. 10.

Polypary 5—10 cm. or more in length, stiff and straight, widening gradually to a maximum breadth of 2·5 mm. Thecæ twelve to nine in 10 mm., those of the proximal portion relatively short and wide, while those of the distal portion have a length of 3 mm., are four times as long as wide, and overlap one-half to two-thirds their length; average inclination 35°—40°.

FIGS. 248 *a* and *b*.—*Monograptus vulgaris*, Wood.

a *b*

a. Proximal end, showing sicula. Figured, Quart. Journ. Geol. Soc., vol. lvi, p. 456, fig. 10 *a*. Trefnant—Middletown Brook, Long Mountain; Lower Ludlow Shales. Coll. Wood.
b. Distal end, showing virgula. Enlargement of part of Pl. XXXVII, fig. 10 *b*.

Description.—The form of the polypary is most characteristic, owing to the stiff and rigid appearance of the proximal portion, and general absence of the ventral curvature so noticeable in *M. dubius*, *M. tumescens*, and other forms.

The sicula has a length of 2 mm., and is about four times as long as wide; it is always conspicuous and reaches to the level of the second thecal aperture.

The early thecæ are short and broad tubes not quite twice as long as wide, and they resemble those of *M. dubius;* the mature thecæ are, however, considerably longer, being fully four times as long as wide.

Affinities.—In the length and characters of the mature thecæ *M. vulgaris*

approaches *M. tumescens* and *M. colonus*, but from both these species it may be readily separated by the characters of the proximal end; from *M. tumescens* it differs also in the entire absence of curvature, and from *M. colonus* not only in this particular but also in the simple character of the early thecæ.

Horizon and Localities.—Wenlock-Ludlow (zones of *Cyrtog. Lundgreni* and *M. vulgaris*).

N. Wales: Road to Deeside Slab Quarries near Tyn-Craig, Moel Ferna. *Welsh Borderland:* Trefnant—Middletown Brook, Long Mountain, etc.; River Irfon near Mill, Builth, etc.

Associates, etc.—*Monog. vulgaris* is an abundant fossil in some localities at the very base of the Lower Ludlow Shales, where it occurs either to the exclusion of all other well-known forms or associated with *M. dubius* and *Gothog. nassa*. It is also found occasionally in the highest Wenlock Shales associated with *Cyrtog. Lundgreni* and *Monog. Flemingii* var. Up to the present time it has only been recorded from N. Wales and the Welsh Borderland.

Collections.—The Authors.

Var. **curtus,** nom. nov. Plate XXXVII, fig. 11.

1900. *M. vulgaris*, var. β, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 457, pl. xxv, fig. 4.

In addition to *Monog. vulgaris* itself there is found a well-marked variety, but at a slightly higher horizon than the typical form; this is shorter and narrower, and has a distinct tendency to ventral curvature of the proximal portion.

The mature thecæ are shorter (2 mm.) and narrower, and are only about three times as long as wide.

Horizon and Localities.—Ludlow (zone of *M. Nilssoni*).

Long Mountain: Lane Farm. *Ludlow District:* Elton Lane?

Associates, etc.—Var. *curtus* occurs rarely in the Ludlow Shales associated with *Monog. bohemicus*.

Collections.—The Authors.

Monograptus tumescens, Wood. Plate XXXVII, figs. 12 *a—d*.

1868. *Graptolites colonus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 540, pl. xx, figs. 9—11.
1889. *Pristiograptus frequens* ?, Jaekel, Zeits. d. d. geol. Gesellsch., vol. xli, p. 669, pl. xxviii, figs. 1, 2.
1900. *Monograptus tumescens*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 458, fig. 11, pl. xxv, figs. 5 A, B.

Polypary 2—4 cm. in length, straight distally but with strong ventral curvature in the proximal portion, widening rapidly to an average

maximum breadth of 2 mm. Thecæ typically eleven to nine in 10 mm., the mature ones about 3 mm. in length, four times as long as wide and overlapping one-half to two-thirds their length; average inclination 30°.

Description.—The polypary is always distinctly incurved in the proximal portion; it attains its maximum breadth rapidly, usually between the seventh and tenth thecæ, and thereafter may show slight decrease in breadth up to the distal extremity; this, however, is not a constant feature. Certain forms from the Lake District are rather shorter and broader than those from Wales and the Welsh Borderland and have more closely set thecæ (thirteen to twelve in 10 mm.).

The sicula has a length of rather less than 2 mm., and is about five times as long as wide; it appears to reach nearly to the upper limit of the second thecal aperture.

FIGS. 249 *a* and *b*.—*Monograptus tumescens*, Wood.

a

b

a. Proximal end, showing sicula. Enlargement of part of Pl. XXXVII, fig. 12 *a*.

b. Distal end, showing virgula. Enlargement of part of Pl. XXXVII, fig. 12 *c*.

The thecæ vary somewhat in number in specimens from different localities, but have invariably the same general characters, and usually show a somewhat thickened apertural margin, which after compression gives rise to a distinct denticle. The proximal thecæ are usually somewhat shorter than those of the distal portion of the polypary.

Affinities.—*Monog. tumescens* is one of the many forms to which the name *M. colonus* has been erroneously assigned. It is, however, clear that it differs widely from that species in the characters of the thecæ of the proximal portion. From *M. dubius*, with which it agrees in many respects, it differs in the rapid widening of the polypary and in the possession of longer, more overlapping thecæ; while from *M. vulgaris*, with which it agrees fairly in the character of the thecæ, it differs in the form of the proximal end and of the polypary in general.

Horizon and Localities.—Lower Ludlow Shales (especially zone of *M. tumescens*).

Montgomeryshire: Llettygynfach (south side of Long Mountain); Montgomery Road. *Ludlow District:* Elton Lane; Gorsty Farm, Elton-Ludlow Road; near Stormer Hall. *Lake District:* Dent.

Associates, etc.—*Monog. tumescens* is a fairly abundant form in the Lower Ludlow Shales, especially in a belt of rocks near the top, where it occurs associated with *M. tumescens*, var. *minor*; it also occurs very occasionally at lower horizons associated with *M. bohemicus* and *M. chimæra*.

Collections.—Sedgwick Museum, Lapworth, and the Authors.

Var. **minor** (McCoy). Plate XXXVII, figs. 13 *a*–*c*.

1855. *Graptolites ludensis*, var. *minor*, McCoy, Brit. Pal. Foss., p. 5.
1900. *Monograptus tumescens*, var. *minor*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 459, pl. xxv, figs. 6 A, B.

A form originally described by McCoy as a variety of *Monog. ludensis* seems to be more probably a variety of *M. tumescens* as here defined. This form agrees with *M. tumescens* in the character of the proximal extremity, and the general shape of the thecæ, while it differs from it in its small size, which never exceeds 13 mm. in length; in fact the general form of the polypary has always a somewhat stunted appearance.

FIG. 250.—*Monograptus tumescens*, var. *minor* (McCoy).

Complete specimen. Enlargement of Pl. XXXVII, fig. 13 *b*.

Horizon and Localities—Lower Ludlow Shales (zone of *M. tumescens*).

Montgomeryshire: Llettygynfach (south side Long Mountain); Llangynyw Rectory, Montgomeryshire. *Ludlow District:* Elton Lane; Elton-Ludlow Road, etc.

Associates, etc.—Var. *minor* appears to occur on the same horizon as the more typical form and as a rule to be associated with it.

Collections.—Lapworth and Wood.

Monograptus comis, Wood. Plate XXXVII, fig. 9.

1900. *Monograptus comis*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 459, pl. xxv, figs. 8 A, B, and fig. 12, p. 460.

FIG. 251.—*Monograptus comis*, Wood.

Proximal end, showing sicula. Enlargement of part of Pl. XXXVII, fig. 9.

Polypary small, not exceeding 2·5 cm. in length, straight distally, but with distinct ventral curvature in the proximal portion, widening gradually throughout till the maximum diameter of about 1·3 mm. is attained. Thecæ eleven in 10 mm., the adult ones with an average length of 2 mm., from three to four times as long as wide, and overlapping about one-half their length; average inclination 25°–30°.

Description.—The polypary is small, and somewhat slender in appearance, with distinct ventral curvature in the proximal portion.

The sicula is about 2 mm. in length, the apex being on a level with the aperture of th. 1, which is rather long.

The thecæ are approximately constant in number throughout the length of the polypary, and their overlap remains approximately the same; the apertural margin shows a tendency to the formation of a distinct flange, which when compressed gives rise to a denticle.

Affinities.—*Monog. comis* presents many resemblances to *M. dubius*, but it is altogether a smaller and more graceful form.

Horizon and Localities.—Lower Ludlow Shales (zone of *M. Nilssoni*).

Ludlow District: Elton-Evenhay Lane; Elton-Ludlow Road.

Associates, etc.—*Monog. comis* has hitherto only been recorded from the Ludlow district, where it occurs in the zone of *M. Nilssoni*.

Collection.—Wood.

Monograptus *cf.* **gotlandicus,** Perner. Plate XXXVII, fig. 8.

1890. *Monograptus* sp., Holm., Gotlands Graptoliter, p. 18, pl. i, figs. 27—30.
1899. *Monograptus gotlandicus*, Perner, Études sur les Graptolites de Bohême, pt. iii, sect. b, p. 12, pl. xiv, fig. 22.
1900. *Monograptus gotlandicus*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 460, pl. xxv, fig. 7.

Polypary rather short, about 3 cm. or rather more in length, with slight ventral curvature in the proximal portion, increasing gradually in width until a breadth of rather more than 2 mm. is attained. Thecæ nine to eight in 10 mm., the adult ones about 3 mm. in length and four and a half times as long as wide, narrowing somewhat in the apertural region, and overlapping one-third to one-half their length; average inclination 25°—35°.

Fig. 252.—*Monograptus* cf. *gotlandicus*, Perner.

Proximal end, showing sicula. Enlargement of part of Pl. XXXVII, fig. 8.

Description.—In its general form the polypary presents no particularly distinctive features; it attains its maximum width fairly gradually.

The sicula seems to have a length of about 2 mm. and to be rather wide at its aperture.

The thecæ, however, are characteristic, particularly as regards a diminution in breadth in the apertural region, with a slight suggestion of the ogee curvature found in the members of the *M. vomerinus* group; they are very long, and the aperture is flanged.

Affinities.—The reference of this British form to *M. gotlandicus* is pro-

visional, nothing but small distal fragments of that species having been figured from Bohemia or Gotland. The characters of the mature thecæ are, however, sufficiently distinctive to make it certain that the British form is at any rate a near ally of Perner's species, to which it is for the present referred.

Horizon and Localities.—Lower Ludlow Shales (zone of *M. Nilssoni*).

Long Mountain District: Old Dingle Mill.

Associates, etc.—One specimen alone is known up to the present; it was found in the zone of *M. Nilssoni*, associated with *Monog. Nilssoni* and *M. varians*.

Collection.—Prof. W. W. Watts.

Monograptus *cf.* **ultimus,** Perner. Plate XXXVII, figs. 14 *a—d*.

1899. *Monograptus ultimus*, Perner, Études sur les Graptolites de Bohême, pt. iii, sect. b, p. 13, text-figs. 14 *a*, *b*, pl. xvi, figs. 4, 5, 11 *a* and *b*.

1900. *Monograptus ultimus*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 461, text-fig. 13, pl. xxv, figs. 9 A and 9 B.

Polypary small and slender, with slight ventral curvature at the proximal termination, not exceeding 2 cm. in length and widening gradually to a maximum breadth of about 1 mm. Thecæ twelve to eleven in 10 mm., the adult ones having a length of 1·6 mm., three to four times as long as wide, with slight tendency to curvature in their walls, and overlapping one-half their length; average inclination 30°—40°.

FIGS. 253 *a—c*.—*Monograptus* cf. *ultimus*, Perner.

a. Complete specimen, natural size. Figured, Quart. Journ. Geol. Soc., vol. lvi, p. 462, fig. 13. Kosoř, Bohemia. Coll. Lapworth.

b. Proximal end, showing sicula. Enlargement of part of Pl. XXXVII, fig. 14 *a*.

c. Distal thecæ. Enlargement of part of Pl. XXXVII, fig. 14 *d*.

Description.—The polypary in *M.* cf. *ultimus* is characteristically small and narrow, and the ventral curvature is confined to the proximal termination in the immediate neighbourhood of the sicula.

The sicula itself is conspicuous, about 2 mm. in length, reaching to the level of the second thecal aperture; it is about five times as long as wide.

The thecæ are somewhat peculiar; they are rather closely set, and though when in relief they may appear to approximate in type to those of *M. dubius*, when compressed they often show slight indications of ogee curvature in the walls; it is possible, therefore, that the axis of the theca was not perfectly straight, and that in this case we are dealing with a type of theca showing an approximation to that characteristic of the *M. vomerinus* group. The direction of the apertural margin also varies somewhat, showing at

times a tendency to become nearly horizontal; usually, however, it is distinctly everted, as is commonly the case with the other members of this group.

Affinities.—The British specimens here described seem to come closest to those forms which Perner has described as *Monog. ultimus*, though as a whole the curvature of the thecal walls is less pronounced in the British than in the Bohemian specimens. *M.* cf. *ultimus* may readily be distinguished from all the species hitherto described by its small size.

Horizon and Localities.—Lower Ludlow Shales (zone of *M. leintwardinensis*).

Long Mountain: Near Frochas. *Lake District:* Helm Knot.

Associates, etc.—The form described above as *Monog.* cf. *ultimus* is not a common fossil in the British Lower Ludlow Shales and no really well-preserved specimens have as yet been found, so that its reference to the Bohemian species is still open to question. It occurs in the zone of *M. leintwardinensis* associated with *M. leintwardinensis* var. *incipiens*.

Collections.—Watts, British Museum (Natural History).

I. B. 1 (*a*).—*Monograpti* in which the thecæ are bi-form and the polypary has dorsal curvature.

Monograptus revolutus, Kurck. Plate XXXVIII, figs. 1 *a*—*e*.

1882. *Monograptus revolutus*, Kurck, Geol. Fören. in Stockh. Förhandl., vol. vi, p. 299, pl. xiv, figs. 2, 3, 4.

1899. *Monograptus revolutus*, Törnquist, Monograptidæ of the Scanian *Rastrites* Beds, Lunds Univ. Årssk., vol. xxxv, pt. 2, no. 1, p. 11, pl. ii, figs. 6—11.

Polypary several cm. in length with involute or broadly recurved proximal portion, widening persistently from a thread-like initial portion till the maximum breadth of rather more than 1 mm. is attained. Thecæ eight to ten in 10 mm., long narrow tubes of two types; the early thecæ with outer extremity of apertural margin retroverted so as to appear somewhat beak-like or as if furnished with a tag or rostel; mature thecæ simple tubes with even apertural margins, overlapping two-thirds their length.

Description.—The form of the polypary is characteristic, especially the gradual increase in breadth from the thread-like initial portion; and, as in the case of *M. cyphus*, there is a considerable amount of variation in curvature in different individuals.

The early portion of the polypary is so slender that its characters are hard to make out; it appears, however, that the delicate sicula alone forms the termination of the polypary, th. 1 arising some distance above its aperture.

The mature thecæ closely resemble those of *M. cyphus*, but the proximal thecæ are of a different type, with a distinct tendency to retroversion of the outer

extremity of the apertural margin. This character is most pronounced close to the proximal end where the thecæ barely overlap at all, and where the appearance presented is almost as if the denticle were prolonged into a definite tag or rostel (*rostellate*). With the increase in length of the thecæ and their increase in the amount of overlap, the tendency to retroversion becomes less and less and the apertural margin is merely somewhat rounded and beak-like (*rostrate*). Finally this tendency disappears, leaving the thecæ for the remainder of the length of the polypary with even and slightly everted apertural margins. The number of thecæ that show this tendency to retroversion varies very much in different specimens, but it is always shown by a considerable number.

FIGS. 254 *a* and *b*.—*Monograptus revolutus*, Kurck.

a. Extreme proximal portion. Rheidol Gorge, Cardiganshire; Rheidol Group (zone of *M. cyphus*). Coll. O. T. Jones.

b. Somewhat more distal thecæ. On same slab as fig. 254 *a*.

Note.—As the form of the whole polypary in these specimens is not known, they may be referable possibly to the succeeding variety—var. *austerus*.

Affinities.—In the form of the polypary *Monog. revolutus* comes closest to *M. cyphus*, but may be readily distinguished from that species by its more slender proximal end and by the character of the proximal thecæ; from its variety var. *præcursor* it differs in the character of the proximal thecæ, which are far less retroverted.

Horizon and Localities.—Llandovery (Birkhill Shales), zones of *M. cyphus* and *M. gregarius*.

S. Scotland: Waterfall, Long Linn, Dobb's Linn; Garple Linn; Frenchland Burn. *C. Wales:* Rheidol Gorge, 400 yards E.S.E. Bryn-chwîth Farm, Pont Erwyd; 235 yards S. of Bryn-chwîth Farm, etc. *N. Wales:* Llanystwmdwy, near Criccieth. *Lake District:* Skelgill. *Ireland:* Side Valley, Mullaghnabuoyagh, Pomeroy; Coalpit Bay, Donaghadee.

Associates, etc.—*M. revolutus* is a fairly abundant fossil in the beds at the base of the zone of *M. grejarius*, and it also ranges up into that zone. It is commonly associated with *Monog. cyphus*, *M. atavus*, *M. Sandersoni*, *Dimorphog. physophora*, *D. confertus*, *Climacog. rectangularis* at the lower horizon, and with *Monog. gregarius*, *M. fimbriatus*, *Climacog. Törnquisti* in the zone of *M. gregarius*.

Collections.—Geological Surveys of England and Wales, and Scotland, Jones, Fearnsides, Lapworth, and the Authors.

Var. **austerus**, Törnquist. Plate XXXVIII, figs. 2 *a*—*c*.

1899. *Monograptus revolutus*, var. *austerus*, Törnquist, Monograptidæ of Scanian *Rastrites* Beds, Lunds Univ. Årssk., vol. xxxv, pt. 2, no. 1, p. 12, pl. ii, figs. 12–14.

In addition to the typical form above described there appears commonly on the same horizon a form in which the polypary is not recurved, but is broadly arcuate throughout its length. This Törnquist has separated as *var. austerus.*

Localities.—S. Scotland: Dobb's Linn. *N. Wales:* Llanystwmdwy. *Ireland:* Coalpit Bay, Donaghadee.

Collections.—Jones, Fearnsides, and the Authors, etc.

Figs. 255 *a—c.*—*Monograptus revolutus*, var. *præcursor*, var. nov.

a. Thecæ of proximal portion. Llanystwmdwy, near Criccieth; Llandovery Beds. Coll. Fearnsides.

b. Proximal thecæ, showing marked retroversion of apertural region. Enlargement of part of Pl. XXXVIII, fig. 3 *a*.

c. Distal thecæ of same specimen.

Var. **præcursor,** var. nov. Plate XXXVIII, figs. 3 *a*, *b*.

In addition to var. *austerus* there is also found another variety of *Monog. revolutus*, which in some respects may be regarded as intermediate in character between *M. revolutus* and *M. difformis*. In the form of the polypary it agrees with *M. revolutus*, but the type of thecæ shows a greater degree of approximation to that of *M. difformis*. The thecal walls show a decided tendency to ogee curvature, and the tendency to retroversion affects not only the apertural margin but also much of the apertural region, so that nearly one-third of the theca becomes free, or technically speaking, *isolate*. The hook-shaped type of theca thus originated becomes common and characteristic in graptolites belonging to higher graptolitic horizons and seems to culminate in the form known as *M. priodon*. This variety may therefore appropriately be termed var. *præcursor*.

Locality.—C. Wales: Rheidol Gorge. *N. Wales:* Llanystwmdwy. *S. Scotland:* Dobb's Linn (?).

Collections.—Geological Survey of England and Wales, Jones, Fearnsides, and Lapworth (?).

Monograptus difformis, Törnquist. Plate XXXVIII, figs. 4 *a—d*.

1899. *Monograptus difformis*, Törnquist, Lunds Univ. Arssk., vol. xxxv, pt. 2, no. 1, p. 13, pl. ii, figs. 15–17.

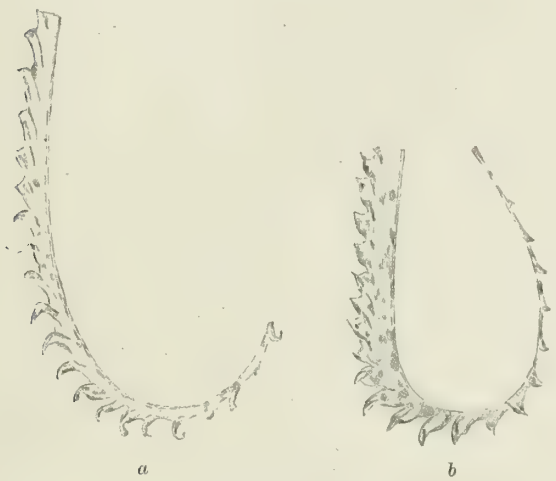
Polypary several cm. in length, arcuate distally, with involute proximal portion, widening gradually till a maximum breadth of about 1 mm. is attained.

Thecæ twelve to ten in 10 mm.; of two types, those of the proximal portion with a tendency to ogee curvature and with conspicuously retroverted apertural region; those of distal portion simple tubes with even and somewhat everted apertural margins; overlapping fully one-half their length.

Description.—The polypary is usually rather smaller in size than that of either *M. revolutus* or its variety *præcursor* and shows more abrupt involution of the proximal extremity; it is also more robust in the proximal portion than either of those forms.

The sicula is small but conspicuous; it measures about 1 mm. in length and the polypary has a breadth of nearly ·3 mm. in its immediate neighbourhood.

FIGS. 256 *a* and *b*.—*Monograptus difformis*, Törnquist.



a. Proximal portion of the polypary. Enlargement of part of Pl. XXXVIII, fig. 4 *a*.
b. Proximal portion of polypary, showing sicula; doubtfully referable to this species. Enlargement of part of Pl. XXXVIII, fig. 4 *d*.

The proximal thecæ show a further development of the tendency to retroversion of the apertural region and fully one-third of the theca is isolate; distally, however, the thecæ gradually lose the curvature of their walls and become simple parallel-sided tubes with even and slightly everted apertural margins. In the proximal thecæ the amount of overlap is very slight, but this steadily increases in amount until distally it is fully one-half of the entire length of the theca.

Affinities.—*Monog. difformis* presents some points of resemblance to *M. revolutus* and its variety *præcursor*. It may, however, be readily separated from *M. revolutus* by the more robust character of the proximal end and the greater retroversion of the proximal thecæ; from var. *præcursor*, however, it differs mainly in the more robust character of the proximal portion of the polypary, the retroversion of the proximal thecæ being very similar in the two forms.

Horizon and Localities.—Llandovery, Birkhill Shales (zone of *Monog. gregarius*).

S. Scotland: Dobb's Linn. *C. Wales:* Rheidol Gorge. *N. Wales:* Llanystwmdwy.

Associates, etc.—*Monog. difformis* apparently occurs in the lower part of the zone of *M. gregarius*, associated with *Monog. fimbriatus* and *M. revolutus*, var. *austerus*. It does not seem to be a common fossil.

Collections.—Jones, Fearnsides, Lapworth, and the Authors.

Monograptus argenteus (Nicholson). Plate XXXVIII, figs. 5 *a*—*d*.

1869. *Graptolites argenteus*, Nicholson, Ann. Mag. Nat. Hist. [4], vol. iv, p. 239, pl. xi, fig. 19.

Polypary 4—6 cm. in length, with straight distal portion and abruptly recurved proximal portion; very slender at origin, widening gradually from a small and inconspicuous sicula to the bend, and thence very rapidly till the maximum breadth of 2·5 mm. is attained. Thecæ long narrow tubes, fifteen to eleven in 10 mm.; in the proximal portion in contact only, with tendency to complete retroversion and isolation of the apertural region; overlap increasing and apertural retroversion decreasing until finally the thecæ of the distal portion are simple tubes, overlapping fully two-thirds their length, with even apertural margins.

FIGS. 257 *a* and *b*.—*Monograptus argenteus* (Nicholson).

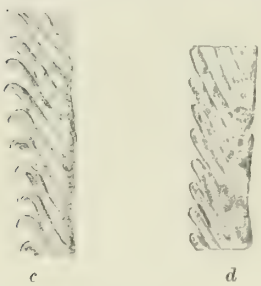
a

b

a. Proximal portion, showing sicula. Llanystwmdwy, near Criccieth; Llandovery Beds. Coll. Fearnsides.
b. Proximal portion of polypary, showing form of thecæ. Ibid.

Description.—The polypary in *Monog. argenteus* is highly characteristic, with its slender straight proximal portion and the rapid change to the robust distal portion after the bend. The whole of the initial portion of the polypary, however, resembles that of *M. limatulus* in its extreme tenuity.

FIGS. 257 *c* and *d*.—*Monograptus argenteus* (Nicholson).



c *d*

c. Proximal-distal thecæ, showing change from one type to the other. Enlargement of part of Pl. XXXVIII, fig. 5 *a*.
d. Distal thecæ. Part of same specimen.

The sicula is small and inconspicuous, barely reaching 1 mm. in length, and failing to reach the level of the aperture of th. 1.

All the early thecæ are small and inconspicuous, apart from the retroverted apertural extremity, which appears somewhat lobate after compression. The retroversion and isolation of the apertural region of the thecæ becomes at first more and more pronounced with remoteness from the sicula, and when the polypary has attained its maximum breadth the thecæ have the appearance of long tubes with a distinct and isolate apertural hook. In the shorter specimens this character may be maintained, with some shortening of the hook, up to the distal termination, but in the longer and more complete specimens it is clear that the retroversion of

the apertural region gradually diminishes, and finally the thecæ are simple tubes, with even and horizontal or slightly everted apertural margins. The mature thecæ are very slender and a horizontal line drawn across the polypary in its distal portion would cut four different thecæ.

Affinities.—As respects its general form, *Monog. argenteus* approaches *M. limatulus*, but distally it is a far larger and more robust species, and the thecæ are different in form.

Horizon and Localities.—Llandovery (Skelgill Beds), sub-zone of *M. argenteus*.

Lake District: Skelgill; Mealy Gill, etc. *N. Wales:* Llanystwmdwy, near Criccieth.

Associates, etc.—*Monog. argenteus* occurs in abundance in a definite band in the Stockdale Shales associated with *Monog. leptotheca*, *M. gregarius*, *M. communis*, *Glyptog. sinuatus*, etc.; and with similar associates at a corresponding horizon in N. Wales.

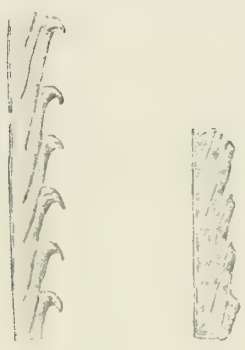
Collections.—British Museum (Natural History), Sedgwick Museum, Fearnsides, Marr, Lapworth, and the Authors.

Var. **cygneus** (Törnquist). Plate XXXVIII, figs. 6 *a*—*d*.

1892. *Monograptus cygneus*, Törnquist, Lunds Univ. Årssk., vol. xxviii, p. 16, pl. i, figs. 28—31.

While the typical *Monog. argenteus* has only as yet been recognised at Llanystwmdwy and in the Lake District, there occurs fairly abundantly in other localities, both at the same horizon and ranging somewhat higher, a form which presents many points of resemblance to it, but is altogether narrower. This seems to come very close to Törnquist's *M. cygneus*, though, as originally described by him, his examples were shorter than is the case with many of our British specimens.

Figs. 258 *a* and *b*.—*Monograptus argenteus*, var. *cygneus*, Törnquist.



a

b

a. Proximal type of thecæ. Enlargement of part of Pl. XXXVIII, fig. 6 *c*.
b. Distal type of thecæ. Part of same specimen.

In this form, which we consider best regarded as a variety of *M. argenteus*, the thecæ, which are of the same general character as those of *M. argenteus*, are inclined at a lower angle, and are more distant (eight in 10 mm.) than those of the typical form; the overlap does not exceed one-half the thecal length, and the polypary has an average breadth in the distal portion not exceeding 1·5 mm. The thread-like proximal portion is rather more than 1 cm. in length, and has precisely the same type of thecæ as has the typical species.

Horizon and Localities.—Llandovery (Birkhill Shales), sub-zone of *M. argenteus* and zone of *M. convolutus*.

S. Scotland: Dobb's Linn, Belcraig Burn, etc. *Lake District:* Skelgill. *C. Wales:* Rheidol Gorge. *N. Wales:* Pary's Mountain, Anglesea.

Associates, etc.—Var. *cygneus* appears to be a commoner form than *M. argenteus*, and takes its place more or less completely in S. Scotland. It is commonly found with *Monog. leptotheca* and *M. concinnus*; and in the Lake District it occurs with *M. argenteus* itself.

Collections.—Sedgwick Museum, Geological Survey of England and Wales, British Museum (Natural History), Greenly, Jones, and the Authors.

Monograptus limatulus, Törnquist. Plate XXXVIII, figs. 7 *a—d.*

1892. *Monograptus limatulus*, Törnquist, Siljansomr. Grapt., Acta Univ. Lund., vol. xxviii, p. 9, pl. i, figs. 6—8.

Figs. 259 *a—c.*—*Monograptus limatulus*, Törnquist.

a

c

b

a. Proximal portion of polypary, mainly preserved as a cast. Llanystwmdwy, near Criccieth; Llandovery Beds. Coll. Fearnsides.
b. Specimen, showing the proximal thecæ. Skelgill; Stockdale Shales (zone of *Monog. convolutus*). Sedgwick Museum.
c. Small proximal fragment in relief. Rheidol Gorge, Cardiganshire. Geol. Survey of England and Wales.

1897. ? *Monograptus limatulus*, Perner, Études sur les Graptolites de Bohême, pt. iii, sect. A, p. 10, pl. xiii, fig. 9.

1899. *Monograptus limatulus*, Törnquist, Monograptidæ of Scanian *Rastrites* Beds, Lunds Univ. Årssk., vol. xxxv, pt. 2, no. 1, p. 14, pl. ii, figs. 18—20.

Polypary short, not exceeding 4 cm. in length, arcuate or straight distally, stiffly and abruptly recurved in proximal portion; very slender and thread-like at origin, but widening abruptly and rapidly at the bend to a maximum breadth of about 1 mm. Thecæ twelve in 10 mm.; those of the proximal portion in contact only, with slightly curved walls and slightly retroverted apertural margins; those of the distal portion simple tubes, overlapping one-half their length, with even everted apertural margins.

Description.—The form of the polypary with its stiff and abrupt recurvature, and slender proximal portion is highly characteristic of this species; so slender, indeed, is the polypary at its proximal extremity that it sometimes appears to taper to a mere

thread, in which in imperfectly preserved specimens it is almost impossible to detect the long, narrow thecæ; these are nearly in contact, and so delicate for the greater part of their length that it almost appears as if the hooked apertural extremities were isolate from each other at considerable distances. There are commonly five or six thecæ of this proximal type; those of the more distal portion are simple tubes of the ordinary "*cyphus*" type.

Affinities.—In the general characters of the proximal end *M. limatulus* approaches *M. argenteus* very closely; it may, however, be readily distinguished by the smooth and even apertural margins of the more distal thecæ and the lesser breadth of the polypary throughout the distal portion.

Horizon and Localities.—Llandovery, Birkhill Shales (zones of *M. convolutus* and *M. Sedgwickii*).

S. Scotland: Dobb's Linn, Moffat; Belcraig Burn, Moffat, etc. *Lake District:* Skelgill. *C. Wales:* Quarry, N.E. Gwen-ffrwd Uchaf Farm, Pont Erwyd. *N. Wales:* Pary's Mountain, Anglesea; Llanystwmdwy, near Criccieth. *Ireland:* Coalpit Bay, Donaghadee.

Associates, etc.—*M. limatulus* occurs in some abundance in the zones of *M. convolutus* and *M. Sedgwickii*; associated with the zone fossil, *M. involutus*, *M. Clingani*, *M. harpago*, and *Cephalog. cometa*, in the zone of *M. convolutus*, and with *M. tenuis*, *Glyptog. serratus* and *Cl. scalaris* in the zone of *M. Sedgwickii;* in the Lake District it occurs with *M. argenteus* in the sub-zone of *M. argenteus*, and in the Pont Erwyd country with *M. leptotheca* at the same horizon. It is only rarely found at any lower horizons.

Collections.—Geological Survey of England and Wales, Geological Survey of Scotland, Sedgwick Museum, Jones, Fearnsides, Lapworth, and the Authors, etc.

I. B. 2: *Monograpti* in which the thecæ are bi-form and the polyparies are approximately straight.

Monograptus colonus (Barrande). Plate XXXVIII, figs. 8 *a*—*d*.

1850. *Graptolithus colonus*, Barrande, Graptolites de Bohême, p. 42, pl. ii, figs. 2, 3.

1852. ? *Graptolithus colonus*, Geinitz, Die Graptolithen . . . der Grauwackenformation in Sachsen, p. 38, pl. ii, figs. 33—36.

1880. *Monograptus Rœmeri*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 151, pl. iv, figs. 5 *a*—5 *e*.

1883. *Monograptus colonus*, Tullberg, Skånes Graptoliter, pl. i, figs. 22 and 23.

1890. *Monograptus colonus*, Geinitz, Die Graptolithen d. k. min. Mus. in Dresden, Mitth. d. k. Min. Geol.-Prähist. Mus. Dresden, pt. ix, pp. 15, 16, pl. A, fig. 14.

1892. *Monograptus colonus*, Barrois, Distribution des Graptolites en France, Ann. Soc. Géol. Nord, vol. xx, p. 100.

1897. *Pristiograptus colonus*, Frech, Lethæa Geognostica, vol. i, pt. iii, pp. 655, 656, fig. 209.

1899. *Monograptus colonus*, Perner, Études sur les Graptolites de Bohême, pt. iii, sect. *b*, p. 9, pl. xiv, figs. 3, 12, 17, text-fig. 12.

1900. *Monograptus colonus*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 463, pl. xxv, figs. 10 A—D, text-fig. 14.

Polypary 4—6 cm. in length, distally straight, but with distinct ventral curvature proximally, widening gradually till the maximum breadth of 2·3 mm. is attained. Thecæ twelve to ten in 10 mm., those of the proximal portion with ogee curvature of walls and retroverted apertural extremities; becoming simpler distally, and finally tubes of uniform width with a length of 3 mm., at least four times as long as wide, overlapping fully two-thirds of their length, and with an average inclination of 35° to 45°. Virgula occasionally prolonged distally.

Description.—The polypary has a characteristic form, the inward curvature of the proximal portion involving the first seven to ten thecæ. The increase in breadth is somewhat rapid at first and is then gradual until the maximum breadth is attained; this is then maintained as a rule to the distal extremity. The virgula may occasionally be observed extending for a short distance beyond the distal extremity of the polypary.

FIGS. 260 *a*—*c*.—*Monograptus colonus* (Barrande).

a *b* *c*

a. Complete specimen preserved in relief, natural size. Figured, Quart. Journ. Geol. Soc., vol. lvi, pl. xxv, fig. 10 A. Butowitz, Bohemia. Coll. Lapworth.

b. Proximal end, showing sicula. Figured, Quart. Journ. Geol. Soc., vol. lvi, p. 464, fig. 14 *a*. Vicarage Road, Builth; Lower Ludlow Shales. Coll. Wood.

c. Distal thecæ in full relief. Vicarage Road, Builth; Lower Ludlow Shales. Coll. Wood.

The sicula, though small (not exceeding 1·6 mm. in length), is usually conspicuous; it reaches to the level of the apertural margin of the second theca.

The four proximal thecæ show the ogee curvature and the retroverted apertural extremities, but these features are most pronounced in th. 1 and th. 2, which are shorter and relatively much broader than any subsequently developed. The mature thecæ are very similar to those characteristic of the preceding group; they have an approximately uniform breadth, straight walls, and an even apertural margin usually devoid of a flange; the thecal length usually increases until it is fully four times the breadth, and may be more.

Specimens from different British localities are apt to exhibit slight variations amongst themselves; these, however, appear to have only a local significance. The specimens from Helm Knot seem to come closest to the accepted Bohemian types; others from Adferton (Ludlow District) appear to widen rather more rapidly and have mature thecæ which are fully five times as long as broad; some from the Builth district resemble the Bohemian forms very closely, whilst others show more conspicuous proximal curvature and rather more closely set thecæ (thirteen

to twelve in 10 mm.), and the polypary as a whole is somewhat longer and narrower.

Affinities.—Many different species of Graptolites have been erroneously referred to Barrande's species *Monog. colonus;* of these the commonest were those later described by Wood as *M. vulgaris*, *M. tumescens*, and *M. varians* (loc. cit. supra). In all four species the distal thecæ resemble each other very closely, but the proximal thecæ and the general characters of the proximal end are different. From *M. vulgaris*, *M. colonus* differs in the curved proximal end and in the characters of the proximal thecæ, from *M. tumescens* in the characters of the proximal thecæ, and from *M. varians* in its wider polypary and somewhat different distal thecæ with their greater overlap.

Horizon and Localities.—Lower Ludlow Shales (zone of *M. Nilssoni*).

Lake District: Helm Knot, Dent; N.E. Casterton Fell. *N. Wales:* Deeside Slab Quarries, Moel Ferna; Hills N.E. Llanrwst; R. bank of Dee, Llangollen, etc. *Welsh Borders:* High Cliff, R. Irfon, near Builth; Vicarage Road, Builth, etc. *Ludlow District:* Elton Lane; Adferton; Trippleton Lane; Bow Bridge, etc.

Associates, etc.—*Monog. colonus* is a fairly abundant fossil in the Lower Ludlow Shales where the Mudstone facies is best developed, as it is in the Builth District; elsewhere it is by no means so abundant as has generally been supposed, though it is essentially a characteristic fossil of the lower part of those shales. It occurs typically in the zone of *M. Nilssoni*, and is usually to be found in association with the zone fossil, *M. bohemicus*, *M. dubius*, and *Gothog. spinosus*.

Collections.—Sedgwick Museum, British Museum (Natural History), Hopkinson, Lapworth, and the Authors, etc.

Var. **compactus** Wood. Plate XXXVIII, figs. 10 *a*—*c*.

1900. *Monograptus colonus*, var. *compactus*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 466, pl. xxv, fig. 12.

Fig. 261.—*Monograptus colonus*, var. *compactus*, Wood.

Distal thecæ. Enlargement of part of Pl. XXXVIII, fig. 10 *a*.

A well-marked variety of *M. colonus* has been appropriately termed var. *compactus*. This agrees with the typical *Monog. colonus* in the shape of the thecæ and character of the proximal extremity, but is distinguished from it (1) by its smaller size (not exceeding 2·5 cm. in length) and more decided curvature; (2) by the densely set thecæ (sixteen to fourteen in 10 mm.), which may overlap as much as three-quarters of their length in the distal portion of the polypary. The virgula is conspicuously prolonged beyond the distal end of the polypary.

Horizon and Localities.—Lower Ludlow Shales (zone of *M. Nilssoni*).

Ludlow District: Elton-Evenhay Lane; Elton Lane; Stormer Hall.

Associates, etc.—Var. *compactus* has up to the present time only been recorded with certainty from the Ludlow District; it may also, however, occur in the Abberley Hills, but this is uncertain. It was found in the zone of *M. Nilssoni* associated with the zone fossil, *M. chimæra* var. *Salweyi*, and *M. varians* var. *pumilus*.

Collections.—Sedgwick Museum, Wood.

Var. **ludensis** (Murchison). Plate XXXVIII, figs. 9 *a*—*c*.

1839. *Graptolithus ludensis*, Murchison, The Silurian System, pl. xxvi, fig. 2.

1879. ? *Graptolithus ludensis*, Quenstedt, Petrefactenkunde Deutschl., vol. vi, pp. 192—193, pl. cl, fig. 29.

1900. *Monograptus colonus*, var. *ludensis*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 465, pl. xxv, fig. 11.

As has already been made clear by Wood (loc. cit. supra) there has been considerable misapprehension concerning this form; the type specimen, now in the collection of the Geological Society of London, is badly preserved, and our personal collection and examination of material from the same locality as that from which Murchison procured his original specimens have unfortunately not completely solved the problem. The specimens are all preserved in a hard calcareous sandstone which weathers deeply, and it is only on the weathered surface that the Graptolites can be seen. As yet it has been impossible to determine with accuracy whether the proximal thecæ really resemble those of *Monog. colonus*; one at any rate appears to show ogee curvature and retroverted apertural extremity, but whether or not there are more thecæ of this type is uncertain. The mature thecæ appear to be somewhat larger than those of *M. colonus* itself, being apparently quite six times as long as wide. For the present it seems best to retain Murchison's name for the specimens from Llanfair, and to regard them as constituting a variety of *M. colonus*. It might, perhaps, be urged that if *M. ludensis* and *M. colonus* probably belong to the same species, the older name —*M. ludensis*—should be applied to both. But Barrande's name—*M. colonus*—has been classic in palæontological literature for the last half century and more, and has obtained such acceptance among Graptolithologists in general that the change would be pedantic.

Fig. 262.—*Monograptus colonus*, var. *ludensis* (Murchison).

Proximal end, showing sicula. Enlargement of part of Pl. XXXVIII, fig. 9 *a*.

Horizon and Locality.—Lower Ludlow (?).

Wales: Llanfair, Montgomeryshire.

Associates, etc.—It has been a little difficult to determine the horizon of var. *ludensis*, but it is almost certainly a Lower Ludlow form; *M. dubius* is its only associate.

Collections.—Geological Society of London; Dr. Humphreys (Llanfair), Wood.

Monograptus varians, Wood. Plate XXXIX, figs. 6 *a*—*e*.

1880. *Monograptus colonus*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 152, pl. iv, figs. 3 *b*—3 *d*.
1900. *Monograptus varians*, Wood, Quart. Journ. Geol. Soc., p. 467, text-fig. 15, pl. xxv, figs. 14 A and 14 B, 15, 16 A and 16 B.

Polypary from 2—2·5 cm. in length, straight with slight ventral curvature near the proximal end, width increasing throughout to a maximum breadth of about 2 mm. or rather less. Thecæ fourteen to ten in 10 mm., typically three at the proximal end show retroverted apertural extremities, those of maturer portion of the polypary simple tubes with very wide apertural margins, 2 mm. in length, from two to three times as long as wide, overlapping one-half their length, and with an average inclination of 30° to 40°. Virgula conspicuous.

FIGS. 263 *a*—*c*.—*Monograptus varians*, Wood.

a. Sicula and th. 1. Specimen on same slab as Pl. XXXIX, fig. 6 *a*.
b. Proximal end. Figured, Quart. Journ. Geol. Soc., vol. lvi, p. 467, fig. 15 *b*. Road above Garbett's Hall, Long Mountain; Lower Ludlow Shales. Coll. Wood.
c. Distal end, showing virgula and character of thecæ. Enlargement of reverse side of part of Pl. XXXIX, fig. 6 *a*.

Description.—The polypary in *Monog. varians* is always short, never apparently exceeding 2·5 cm. in length and generally being only about 2 cm.; the increase in breadth takes place fairly rapidly in the proximal portion, and thence is more gradually continued right up to the distal extremity. The virgula is generally very conspicuous at the distal end of the polypary.

The sicula has a length of about 2 mm. and is long relatively to its breadth, reaching well above the level of the second thecal aperture.

The ogee form of the proximal thecæ is not nearly so conspicuous as in *M. colonus*, though there are distinct traces of it in th. 1; all the earliest three thecæ may have retroverted apertural extremities, though this feature is sometimes not discernible in th. 3. In the thecæ developed later the great width of the apertural margin is often associated with a distinct compression of the ventral wall of the theca next above, resulting in a most characteristic appearance. In

the proximal portion of the polypary the thecæ are barely twice as long as wide, but the length increases in the distal portion.

Affinities.—At first sight this form appears to resemble *M. colonus* very closely ; the polypary, however, is in reality shorter and narrower, it increases more uniformly in breadth throughout its length, and the characters of the adult thecæ are different.

Horizon and Localities.—Lower Ludlow Shales (zone of *M. Nilssoni*).

Long Mountain District: Winnington Green; Old Dingle Mill; Garbett's Hall; Trefnant-Middletown Brook. *Ludlow District:* Mary Knoll; Elton Lane.

Associates, etc.—*Monog. varians* seems to take the place of *M. colonus* in the Lower Ludlow Shales of the Long Mountain District, where it occurs in some abundance associated with *Monog. Nilssoni*, *M. dubius*, and *M. varians* var. *pumilus*; it also occurs, though rather less commonly, in the Ludlow District at the same horizon, associated with *M. Nilssoni*, *M. chimæra* var. *Salweyi*, and *M. dubius*.

Collections.—Sedgwick Museum, Hopkinson, Lapworth, and the Authors.

Note.—*Monog. varians* is remarkable in presenting certain local variations, and on approximately the same horizon, so far as can be judged. It occurs at several localities in large numbers in the Long Mountain District; at some of these it is small, and only the *two* basal thecæ are retroverted at their apertures. At Dingle Mill its length is normal, but so far as can be seen only *one* theca shows a retroverted aperture; while at Garbett's Hall it is still long but with two basal thecæ showing the retroverted character. Again, in the Trefnant-Middletown Brook it is somewhat broader than usual, and the first three thecæ are all retrovert. In all cases the fossils seem to occur in association with *M. Nilssoni*.

The description as given above includes Wood's var. *α* and var. *β*, which are probably inconstant local varieties.

FIGS. 264 *a*—*c*.—*Monograptus varians*, var. *pumilus*, Wood.

a. Proximal end, showing sicula. Elton Lane, Ludlow; Lower Ludlow Shales. Coll. Wood.

b. Distal thecæ. Abberley Hills; Lower Ludlow Shales. Coll. Wickham King.

c. Complete specimen, showing sicula and thecal growth lines, preserved as a cast. Figured in part, Quart. Journ. Geol. Soc., vol. lvi, p. 469 fig. 16 *c*. Round Hill, Abberley; Lower Ludlow Shales. Coll. Wickham King.

Var. **pumilus**, Wood. Plate XXXIX, figs. 7 *a*—*e*.

1900. *Monograptus varians*, var. *pumilus*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 469, text-fig. 16, pl. xxv, figs. 17 A, 17 B.

While allowing for a certain amount of local variation in the species *M. varians*, there is one form which, having a longer range than the typical species and other more definite characters, seems worthy of distinction, and has been described by Wood as var. *pumilus*. This variety is invariably small in size, rarely exceeding 1·2 cm. in length,

the proximal curvature is very slight, the sicula extends to nearly the level of the aperture of th. 3, and the thecæ are very closely set (sixteen to fourteen in 10 mm.).

Horizon and Localities.—Lower Ludlow Shales (zones of *M. Nilssoni* and *M. scanicus*).

Ludlow District: Elton Lane; Elton-Evenhay Lane; Stormer Hall; Abberley Hills.

Associates, etc.—Var. *pumilus* has a very characteristic gregarious habit, often occurring in dense crowds on slabs of rock almost to the exclusion of any other form. It occurs in the zone of *M. Nilssoni* associated with the zone fossil, *M. colonus* var. *compactus*, *M. dubius*, and *M. varians*; and in the zone of *M. scanicus* with *M. scanicus*, *M. chimæra*, and *M. chimæra* var. *Salweyi*.

Collections.—Sedgwick Museum, Wickham King, and the Authors.

Monograptus Roemeri (Barrande). Plate XXXIX, figs. 2 *a*—*d*.

1850. *Graptolithus Rœmeri*, Barrande, Graptolites de Bohême, p. 41, pl. ii, figs. 9—11.
1869. *Monograptus Rœmeri*, Heidenhain, Zeitschr. d. deutsch. geol. Gesellsch., vol. xxi, p. 150, pl. i, fig. 5.
1879. *Graptolithus colonus*, Quenstedt, Petrefactenkunde Deutschl., vol. vi, pl. cl, fig. 40.
1883. ? *Monograptus colonus*, Tullberg, Skånes Graptoliter, pl. i, fig. 21.
1884. *Monograptus Rœmeri*, J. D. La Touche, Handbook to the Geology of Shropshire, p. 78, pl. xviii, fig. 578.
1897. *Pristiograptus Rœmeri*, Frech, Lethæa Geognostica, pt. iii, p. 656, fig. 210.
1899. *Monograptus Rœmeri*, Perner, Etudes sur les Graptolites de Bohême, pt. iii, sect. *b*, p. 8, pl. xiv, figs. 1, 7, 10, 18, 24, text-fig. 11.
1900. *Monograptus Rœmeri*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 470, text-fig. 17, pl. xxv, figs. 13A, 13B.

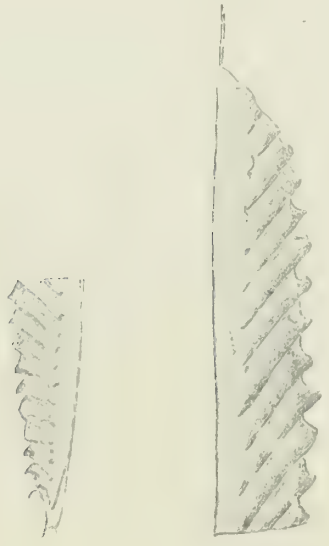
Polypary 3—8 cm. in length, with slight ventral curvature proximally and slight dorsal curvature distally, increasing rapidly in width at first and then more gradually till the maximum breadth of about 3 mm. is attained. Thecæ sixteen to eleven in 10 mm.; two proximal ones with retroverted apertural extremity; the rest approximately straight-walled simple tubes increasing in length distally till they measure 4 mm. or more in length, five or five and a half times as long as wide, overlapping fully two-thirds their length, and having an average inclination of 40° to 45°.

Description.—The form of the polypary of *Monog. Roemeri* with its slight double curvature is highly characteristic, as is also its rapid increase in width in the proximal portion.

The sicula has a length of about 1·8 mm., and it extends well above the apertural margin of the second theca.

The thecæ are also markedly characteristic of the species, only two show traces of ogee curvature and retroversion of the apertural extremity, in neither case very pronounced. The great length of the thecæ in proportion to their breadth in the mature portion of the polypary is most noticeable, as is also their high angle of inclination and amount of overlap. There is occasionally a tendency to diminish in breadth in the distal portion of the polypary, but this may only signify immature development of the thecæ.

Figs. 265 *a* and *b*.—*Monograptus Roemeri* (Barrande).



a *b*

a. Proximal end, showing sicula. Enlargement of reverse side of part of Pl. XXXIX, fig. 2 *a*.
b. Distal thecæ in relief. Helm Knot, Dent; Coniston Grits. Sedgwick Museum.

Affinities.—*Monog. Roemeri* is undoubtedly closely related to *M. colonus*, but it can be easily separated from that species by the greater length of the mature thecæ.

Horizon and Localities.—Lower Ludlow Shales (zones of *M. Nilssoni* and *M. scanicus*) and their equivalents.

Ludlow District: Elton Lane; Elton-Ludlow Road. *Long Mountain District:* Trefnant-Middletown Brook. *Lake District:* Helm Knot, Dent. *Staffs.:* Dudley, Walsall. *Welsh Borders:* Aberedw Hill, Builth.

Associates, etc.—*Monog. Roemeri* is not a common fossil in British rocks; it occurs, however, in the zone of *M. Nilssoni* associated with the zone fossil and *M. colonus*, and at a higher horizon with *M. scanicus* and *M. chimæra*.

Collections.—Sedgwick Museum, Univ. of Birmingham, Lapworth, and Wood.

Monograptus chimæra (Barrande). Plate XXXIX, figs. 3 *a*—*d*.

1850. *Graptolithus chimæra*, Barrande, Graptolites de Bohême, p. 52, pl. iv, figs. 34, 35.
1889. *Pristiograptus colonus*, Jaekel (?), Zeitschr. d. deutsch. geol. Gesellsch., vol. xli, p. 674, pl. xxviii, fig. 8.
1899. *Monograptus chimæra*, Perner, Études sur les Graptolites de Bohême, pt. iii, sect. *b*, p. 14, pl. xvii, figs. 15 *a*, *b*.
1900. *Monograptus chimæra*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 471, pl. xxv, figs. 18 A—D.

Polypary 2—4 cm. in length, straight distally, but with slight ventral curvature in the proximal portion, increasing rapidly in width at first and then more gradually till the maximum breadth of 2 mm. is attained. Thecæ thirteen to eleven in 10 mm., appearing as somewhat hexagonal prisms with spined

apertural margin, having a length of 2 mm., four times as long as wide, and overlapping one-half their extent; average inclination high—40°–50°.

Description.—In the general form and characters of the polypary as a whole apart from the spines, *Monog. chimæra* is somewhat like *M. colonus*, but it is typically shorter and broader.

The thecæ are very distinctive and present different appearances according to the direction and amount of compression. When the thecæ are shown in profile the spine has a curious position, originating, as it were, from the angle of a cusp situated in the middle of the apertural margin (Fig. 266 *a*). In other cases, however, in which the thecæ seem to narrow somewhat in the apertural region, the spine appears to be in a more usual position, and to come off where the ventral wall meets the apertural edge. The spines of the proximal thecæ appear to be always in this latter position, and it is possible that these thecæ, which certainly show signs of ogee curvature of their walls and retroversion of their thecal apertures, are different in shape from those of the more distal portions of the polypary. The appearance of the mature thecæ suggests that they were more or less hexagonal in section; indeed, in one specimen, preserved so that the apertures face the observer, one or two of the thecæ are definitely hexagonal (Fig. 266 *b*). The apparent anomalies in the position of the spines would thus be explained by their coming off from one of the angles made by the walls of the hexagonal prism with the apertural margin. The various positions assumed by the spines under different conditions of preservation may be seen from the figures. The spines are commonly stout and do not exceed ·6 mm. in length.

Figs. 266 *a* and *b*.—*Monograptus chimæra* (Barrande).

a *b*

a. Complete specimen, profile view; in relief. Walsall, Staffs; Lower Ludlow Shales. Coll. Lapworth.

b. Specimen, sub-ventral view, showing form of thecal apertures. Elton Lane, Ludlow; Lower Ludlow Shales. Coll. Wood.

The sicula has a length of nearly 2 mm., and extends to midway between the apertures of th. 2 and th. 3.

Affinities.—The spined character of the thecæ separates *Monog. chimæra* from all other forms of the *M. colonus* group except its own variety *Salweyi* and *M. leintwardinensis*. From the former of these it may be readily distinguished by its shorter, stouter spines, and longer and more curved polypary. In *M. leintwardinensis* the spines are mesial in position and not apertural, except in the proximal portion, where the thecæ agree closely in form with those of *M. chimæra*.

Horizon and Localities.—Lower Ludlow Shales (zones of *M. Nilssoni* and *M. scanicus*).

Ludlow District: Elton-Ludlow Road; Elton Lane. *Staffs.:* Walsall; Wren's Nest, Dudley. *Welsh Borders:* Aberedw Hill, Builth; Ucheldre Stream, Long Mountain.

Associates.—*Monog. chimæra* occurs typically in the zone of *M. scanicus*, associated with the zone fossil and *M. Roemeri*, but it is also found at a somewhat lower horizon with *M. Nilssoni*, *M. bohemicus*, and *M. dubius*. It is not a very abundant fossil.

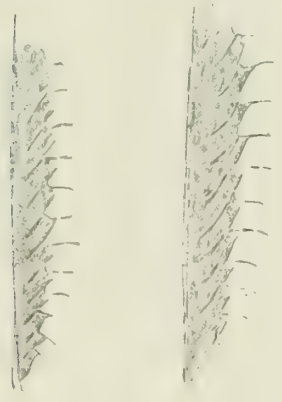
Collections.—Lapworth, University of Birmingham, Wood.

Var. **Salweyi** (Hopkinson MS.). Plate XXXIX, figs. 5 *a*—*d*.

1880. *Monograptus Salweyi*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 150, pl. iv, figs. 2 *a*—*b*.
1884. *Monograptus chimæra*, J. D. La Touche, Handbook to the Geology of Shropshire, p. 77, pl. xviii, fig. 571.
1900. *Monograptus chimæra*, var. *Salweyi*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 472, text-fig. 18, pl. xxv, figs. 19 A, B.

Monog. chimæra var. *Salweyi* was originally named by Hopkinson as a distinct species, and his type specimen, which shows only the distal extremity, was figured by Lapworth.

FIGS. 267 *a* and *b*.—*Monograptus chimæra*, var. *Salweyi* (Hopkinson).



a. Complete specimen, showing sicula. Figured Quart. Journ. Geol. Soc., vol. lvi, p. 473, fig. 18 *a*. Stormer Hall, nr. Leintwardine; Lower Ludlow Shales. Coll. Wood.
b. Distal thecæ, showing thecal spines. Ibid., fig. 18 *b*.

As Wood, however, has already shown (*loc. cit. supra*), the collection of more material from the type locality has revealed the close connection between this form and *M. chimæra*, and it is best regarded as a variety of the species last described.

Var. *Salweyi* differs from *M. chimæra* itself in—(1) Its smaller size—it appears rarely to exceed 1·3 cm. in length and 1·6 mm. in breadth; (2) the straighter character of the proximal end; (3) the longer, slender, and more flexed thecal spines, which may be fully 1 mm. in length. The virgula is usually a conspicuous feature at the distal end of the polypary.

Horizon and Localities.—Lower Ludlow Shales (zone of *M. Nilssoni*).

Ludlow District: Stormer Hall, near Leintwardine; Elton-Evenhay Lane. *Long Mountain:* Lettygynfach.

Collections.—Hopkinson, Wood.

Var. **semispinosus,** nom. nov. Plate XXXIX, figs. 4 *a—c.*

1900. *M. chimæra* var. *a*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 473, pl. xxv, fig. 20.

This variety bears precisely the same relation to *M. chimæra* that var. *incipiens* does to *M. leintwardinensis;* it differs from *M. chimæra* in being somewhat broader (2·5 mm.), and above all in having the distal thecæ devoid of spines altogether, while the proximal thecæ are spined in the usual manner.

Horizon and Localities.—Lower Ludlow Shales (zone of *M. scanicus*).

Ludlow District: Elton Lane; Elton-Ludlow Road.

Var. *semispinosus* is only found in the zone of *M. scanicus*, where it occurs in association with the zone fossil and *M. varians* var. *pumilus*.

Collections.—Lapworth and Wood.

Monograptus leintwardinensis, Hopkinson MS. Plate XXXIX, figs. 8 *a—f.*

1880. *Monograptus leintwardinensis*, Hopkinson (MS.), Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 149, pl. iv, fig. 1.

1884. *Monograptus leintwardinensis*, J. D. La Touche, Handbook to the Geology of Shropshire, p. 77, pl. xviii, fig. 574.

1897. *Pristiograptus uncinatus*, Frech, Lethæa Geognostica, pt. iii, p. 658, fig. 213.

1900. *Monograptus leintwardinensis*, Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 474, text-fig. 19, pl. xxv, figs. 21 A, B.

FIGS. 268 *a—c.*—*Monograptus leintwardinensis*, Hopkinson.

a. Complete specimen, showing sicula. Enlargement of part of Plate XXXIX, fig. 8 *a*.

b. Complete specimen, showing various positions of thecal spines. Figured Quart. Journ. Geol. Soc., vol. lvi, p. 474, fig. 19 *b*. Church Hill Quarry, Leintwardine; Lower Ludlow Shales. Coll. Lapworth.

c. Distal thecæ, showing paired spines. On same slab as Plate XXXIX, figs. *c—f*. Lower Ludlow Shales. Coll. Fearnsides.

Polypary short, seldom exceeding 1·3 cm. in length, straight distally, but with slight curvature in the proximal portion, increasing gradually in width until the maximum breadth of 1·6 mm. is attained. Thecæ spined, fourteen to fifteen in 10 mm.; those of the distal portion fairly short tubes with a length of about 2 mm., and about three times as long as wide, overlapping one-half to two-thirds their length; those of the proximal portion with slight ogee curvature and retroverted and spined apertural margins.

Description.—The polypary is always short and narrow; it widens gradually for the first five or six thecæ and has then attained its maximum breadth, which is maintained to the distal extremity.

The sicula is long and conspicuous; it measures 2·1 mm. in length, extending to midway between the apertures of th. 2 and th. 3.

The thecæ of the extreme proximal portion show a tendency to ogee curvature in their walls and appear to have retroverted and spined apertural margins. The spines of the mature distal thecæ *seem* to be mesial in position, but this is possibly deceptive and due to compression, as their apparent point of origin is by no means constant in different individuals. Although in most cases only one spine is visible on each theca, yet it would appear from certain specimens (fig. 268 *c*) that a pair of spines is really present.

Affinities.—*Monog. leintwardinensis* is a most characteristic species, which, however, is closely allied to *M. chimæra* and its varieties; the proximal thecæ are certainly similar, but the spines of the distal thecæ, so far as can be determined, appear to be different in position.

Horizon and Localities.—Ludlow Shales (Aymestry Limestone), zone of *M. leintwardinensis.*

Ludlow District: Church Hill, Leintwardine; Adferton; Trippleton; Aymestry; Vinnall; Ludlow Road; Broxton and Burton. *Welsh Borders:* Lettygynfach, Long Mountain; Aberedw, near Builth; Presteign, Old Radnor; Launwell Dingle. *Lake District:* Near Knock, etc. *Dee Valley:* Pen-y-vivod; Llantisilio Road.

Collections.—Sedgwick Museum, Fearnsides, Lapworth, and the Authors, etc.

Var. **incipiens,** Wood. Plate XXXIX, figs. 9 *a—d.*

1900. *Monograptus leintwardinensis,* var. *incipiens,* Wood, Quart. Journ. Geol. Soc., vol. lvi, p. 474, pl. xxv, figs. 22 A, B.

Fig. 269.—*Monograptus leintwardinensis,* var. *incipiens,* Wood.

Complete specimen, showing sicula. Montgomery Road; Lower Ludlow Shales. Coll. Wood.

This variety of *Monog. leintwardinensis* agrees with the typical form in general, except that it is somewhat broader (2—2·3 mm.) and longer, and that only its proximal thecæ are spined. It bears the same relation to the typical form that var. *semispinosus* does to *M. chimæra.* It has never been found, hitherto, in association with the typical form, and may be merely a local variant.

Horizon and Localities.—Lower Ludlow Shales (near summit).

Welsh Borders: Montgomery Road; Rose and Crown Inn, Long Mountain; Lower Winnington, etc. *Lake District:* Tebay Gill, Bannisdale.

Associates.—Var. *incipiens* seems to occur at a rather lower horizon than the typical *M. leintwardinensis*; its only known associate is *M. cf. ultimus.*

Collection.—Watts, Wood.

Group II.

Monograpti in which the mature thecæ are tubes with flowing sigmoid curvature and oblique apertural margins.

The Graptolites included in this group vary a good deal in the amount of sigmoid curvature of their thecal walls. Most of the species typically possess thecæ resembling those of *Leptograptus;* but the group includes at the one extreme *M. atavus*, a form in which the thecæ are not very much curved, and at the other extreme *M. argutus*, in which the thecæ have marked curvature and both introversion and introtorsion of the apertural margin, characters approximating to those typical of the *Dicellograpti.*

The group includes the following species: *Monograptus atavus*, *M. Sandersoni*, *M. incommodus*, *M. tenuis*, *M. argutus.*

Monograptus atavus, Jones. Plate XXXIX, figs. 1 *a—d.*

1909. *Monograptus atavus*, Jones, Quart. Journ. Geol. Soc., vol. lvi, p. 531, figs. 18 *a—d.*

Polypary very long and slender, with slight dorsal curvature proximally, but sometimes slightly ventral in its distal portion, widening gradually from an almost thread-like proximal extremity to a maximum breadth of 1·2 mm. Thecæ nine to eight in 10 mm., simple tubes with varying amount of sigmoid curvature and slight introversion of the apertural margin, which, however, diminishes distally; overlap never exceeding one-half the thecal length.

Description.—Monog. atavus must have attained a very great length, probably fully 30 cm. or more. The widening is almost imperceptible in the proximal portion, but the greater number of distal fragments have a uniform breadth, so that the maximum width must have been attained at a comparatively early stage.

The sicula is but rarely seen; it seems to have a length of nearly 2 mm. and to form the proximal termination of the polypary; it does not reach to the level of the aperture of th. 1.

The thecæ are relatively rather short (1·5—2·5 mm. in length), and are of the general type of those of the Leptograptidæ; the sigmoid curvature of the walls is constant, but appears to vary somewhat in amount in different specimens (compare Figs. 270 *c* and 270 *e*). The distinct introversion of the apertural margin of the proximal thecæ disappears distally, when the thecal margins may be even slightly everted. The number of thecæ per centimetre is fairly constant throughout the length of an individual, the overlap increasing with the general increase in length of the theca.

Affinities.—*Monog. atavus* comes, perhaps, closest to *M. tenuis*, Portlock, with which species it was confounded until recently. The thecæ of *Monog. atavus* are, however, shorter and more closely set, and also inclined at a higher angle; the apertural margins, too, are even and devoid of the denticles or rostels frequently found in *M. tenuis*. *Monog. atavus* also shows some resemblance to *M. argutus*; but the thecal walls are less curved, and the apertural margins are not introtorted.

FIGS. 270 *a*—*e*.—*Monograptus atavus*, Jones.

a *b* *c* *d* *e*

a. Proximal fragment, showing sicula almost complete. Rheidol Gorge, Cardiganshire: Rheidol Group (zone of *M. atavus*). Coll. Jones.
b. Proximal portion, showing part of sicula. Ibid.
c. Proximal portion in relief, showing sinuous character of thecæ. Figured, Quart. Journ. Geol. Soc., vol. lxv, p. 533, fig. 18 *b*. Rheidol Gorge. Coll. Geol. Survey of England and Wales (No. 23710).
d. More distal thecæ; part in relief, part cast. Ibid.
e. Ibid. Part of Fig. 18 *c* (No. 23707).

Horizon and Localities. — Llandovery (Birkhill Shales), zones of *Orthog. vesiculosus*, *M. cyphus* and *M. gregarius*.

S. Scotland: Dobb's Linn; Belcraig Burn. *Ireland:* Coalpit Bay, Donaghadee; Mill Sluice below Slate Quarry, Pomeroy. *Lake District:* Skelgill; Spengill. *Wales:* Rhayader; Rheidol Gorge, Pont Erwyd; Pary's Mountain, Anglesea; Llanystwmdwy.

Associates, etc.—*Monog. atavus* is the first *Monograptus* to make its appearance in geological time. In S. Scotland it appears considerably below the base of the *M. cyphus* zone in the zone of *Orthog. vesiculosus*, and ranges up into the zone of *M. cyphus* associated with *M. cyphus*, *M. Sandersoni*, and various *Dimorphograpti*; at Skelgill it is found in the *Dimorphograptus* band; in the Pont Erwyd district also it appears in a band by itself before the coming in of *M. cyphus*. In the succeeding zone of *M. gregarius* it is not so abundant, but is found associated with *M. fimbriatus*, *M. gregarius*, and other forms.

Collections.—Geological Survey of England and Wales, Sedgwick Museum, H. Lapworth, Jones, Lapworth, and the Authors.

Monograptus Sandersoni, Lapworth. Plate XXXIX, figs. 10 *a*—*e*.

1876. *Monograptus Sandersoni*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 320, pl. xi, fig. 2 *a*–*e*.

Polypary slender, of great length, with distinct ventral curvature proximally, and becoming straighter distally; widening almost imperceptibly from a thread-like proximal portion to a maximum of about ·7 mm. Thecæ eight to six in 10 mm., very long and narrow, inclined at so low an angle that their inner walls form an almost continuous line running parallel to the axis of the polypary, overlapping one-half their length, and with distinctly introverted apertural margins.

Description.—The polypary is always slender, and shows ventral curvature especially in the proximal portion, in which it is very pronounced in some individuals (see Plate XXXIX, fig. 10 *b*). Distally the amount of curvature tends to decrease as a general rule, and fragments appear practically straight.

Owing to the extreme tenuity of the proximal end it is difficult to find the sicula preserved, but it appears to be at least 1·6 mm. in length, and to form the proximal termination of the polypary (Fig. 271 *a*).

Figs. 271 *a*—*d*.—*Monograptus Sandersoni*, Lapworth.

a. Proximal portion, showing the sicula in part. On same slab as Pl. XXXIX, fig. 10 *c*.

b. Proximal thecæ, showing various views of apertural margins. Dobb's Linn; Birkhill Shales. Coll. Lapworth.

c. Distal thecæ, showing introverted apertural margins. E. bank of road from Pont Erwyd to Devil's Bridge; Castell Group. Geol. Survey of England and Wales.

d. Distal thecæ, slightly different view. Enlargement of part of reverse of specimen figured on Plate XXXIX, fig. 10 *e*.

The thecæ are characteristic; they resemble very closely those regarded as typical of the genus *Leptograptus*, with sigmoid curvature of their walls and introversion of the apertural margins; they are commonly 2·5 mm. in length, and overlap one-half their length as a maximum.

Affinities.—In the characters of the thecæ and general tenuity of the polypary *Monog. Sandersoni* approaches *M. incommodus*, but differs markedly in the curvature of the polypary. The two species may readily be distinguished except in small distal fragments, which are very similar.

Horizon and Localities. — Llandovery (Birkhill Shales), especially zone of *M. cyphus*.

S. Scotland: Waterfall, Long Linn, Dobb's Linn; Frenchland Burn; Belcraig Burn, etc. *Lake District:* Skelgill, etc. *Ireland:* Coalpit Bay, Donaghadee. *Wales:* East bank of road, 50 yds. E.N.E. of Brynchwîth Farm House, Pont Erwyd; Rheidol Gorge, 400 yds. E.S.E. of same, Pont Erwyd, etc.

Associates, etc.—*Monog. Sandersoni* occurs in Scotland in some abundance in the zone of *M. cyphus*, associated with *M. cyphus*, *M. revolutus*, *M. atavus*, *M. incommodus*, *Dimorphog. physophora*, *Climacog. medius* and other forms. It occurs on a similar horizon in the Lake District in the *Dimorphog. confertus* band associated with *M. incommodus* and *M. atavus;* and also in Central Wales and Ireland. In S. Scotland, Ireland and C. Wales it also ranges up into the lower beds of the succeeding zone of *M. gregarius*, where it is associated with *M. fimbriatus*, *M. gregarius*, *M. triangulatus* var., *Climacog. Törnquisti* and other forms.

Collections.—Geological Survey of England and Wales, Sedgwick Museum, Lapworth, Jones, and the Authors.

Monograptus incommodus, Törnquist. Plate XL, figs. 1 *a—e*.

1899. *Monograptus incommodus*, Törnquist, Monograptidæ of Scanian *Rastrites* Beds Lunds Univ. Arssk., vol. xxxv, pt. 2, no. 1, p. 11, pl. ii, figs. 1—5.

Polypary long and slender, with irregular curvature, widening from a slender, slightly arcuate, or straight proximal portion to a flexed distal portion with an average breadth of ·6 mm. Thecæ eight to seven in 10 mm., inclined at a very low angle and overlapping one-third to one-half their length; apertural margins even and slightly introverted.

FIGS. 272 *a—e*.—*Monograptus incommodus*, Törnquist.

a. Proximal end, showing sicula. Dobb's Linn; Birkhill Shales. Coll. Lapworth.
b. More distal thecæ. Part of specimen on same slab as Fig. 272 *a*.
c. Thecæ preserved in relief. Llanystwmdwy, near Criccieth; Llandovery beds. Coll. Fearnsides.
d. Thecæ, showing appearance of introverted apertural margins; in relief. Enlargement of part of Pl. XL, fig. 1 *b*.
e. Distal thecæ, compressed. Enlargement of part of Pl. XL, fig. 1 *c*.

Description.—The polypary is very long, slender and flexed, the curvature being, however, generally dorsal; the proximal end is very slender (though not so slender as in *M. Sandersoni*), but widens fairly rapidly to the maximum breath of ·5 mm.

The sicula has a length of fully 3 mm., and reaches to the level of the aperture of th. 1 which arises from a point about half-way along its length.

The thecæ resemble those of *M. Sandersoni*, but the introversion of the apertural margin appears to be slightly less marked.

Affinities.—*Monog. incommodus* is clearly related most closely to *M. Sandersoni*; but while the curvature in *M. incommodus* is mainly dorsal or irregular, in *M. Sandersoni* it is invariably ventral; and the polypary is rather more robust at the proximal end.

Horizon and Localities.—Llandovery (Birkhill Shales), zone of *M. cyphus*.

S. Scotland: Dobb's Linn; Belcraig Burn, etc. *Lake District:* Skelgill. *Ireland:* Coalpit Bay, Donaghadee; Mill Sluice below Slate Quarry, Pomeroy. *Wales:* Rheidol Gorge, Pont Erywd; Conway; Pary's Mountain, Anglesea; Llanystwmdwy, near Criccieth.

Associates, etc.—*Monog. incommodus* is a fairly common fossil in the zone of *M. cyphus*; it is commonly associated with *Monog. cyphus*, *M. revolutus*, *M. Sandersoni*, *M. atavus*, various *Dimorphograpti*, and *Climacog. medius*.

Collections.—Sedgwick Museum, Geological Survey of Scotland, Geological Survey of England and Wales, Fearnsides, Jones, Lapworth, and the Authors.

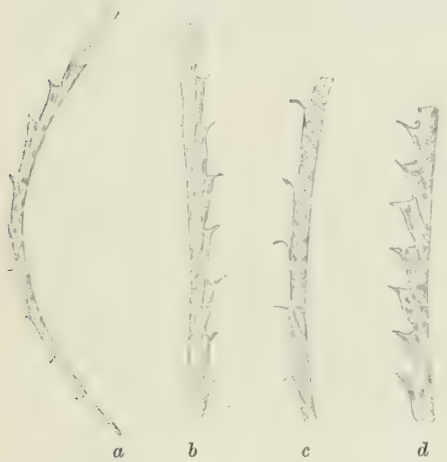
Monograptus tenuis (Portlock). Plate XL, figs. 2 *a*—*e*.

1843. *Graptolites tenuis*, Portlock, Geol. of Londonderry, p. 319, pl. xix, fig. 7.
1868. *Graptolites discretus*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, p. 539, pl. xx, figs. 12—14.
1876. *Monograptus tenuis*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 319, pl. xi, figs. 3 *h*, *k*, *l*, *m*, *n*.

Polypary of great length, slightly arcuate throughout, widening gradually from an exceedingly slender proximal portion till the maximum breadth of 1 mm. is attained. Thecæ seven to five in 10 mm., long and narrow, with distinct sigmoid curvature, overlapping one-third to one-half their length; those of the proximal portion with abrupt expansion in the apertural region and usually introverted, those of the distal portion even and slightly introverted.

Description.—The polypary must have had a length of fully 10—15 cm., and though in the extreme proximal portion it appears to widen very gradually, it attains its maximum breadth at a comparatively early stage, usually within the first 4 or 5 cm. of its length.

Figs. 273 *a*—*d*.—*Monograptus tenuis* (Portlock).



a. Proximal portion. Enlargement of part of Pl. XL, fig. 2 *c*.
b. Distal thecæ in ordinary profile view. Enlargement of specimen on same slab as fig. 273 *a*.
c. Thecæ not in ordinary profile view, giving appearance of thecal spine. Ibid.
d. Distal thecæ. Enlargement of part of Pl. XL, fig. 2 *a*.

The thecæ are long and slender; they show a sigmoid curvature of their walls as in the genus *Leptograptus*, but the apertural margin, while always tending to be introverted, is not always conspicuously so, owing to the effects of compression upon the thecæ, which expand abruptly in the apertural region. In the proximal portion this may give rise to an appearance of retroversion of the apertural margin in some cases (though in other cases it is clearly introverted), and in the case of the mature thecæ of the distal portion may tend to the production of an acute denticle. The thecæ are distant and overlap each other barely one-half their length.

Affinities.—For a considerable time *Monog. tenuis*, Portlock, and *M. discretus*, Nicholson, have been regarded by some as different species, but an examination of Portlock's Irish specimens and new material collected from the type locality shows that the two are identical. A distinct form which occurs at lower horizons, and which has been erroneously referred to *M. tenuis* by various authors, has recently been distinguished and described by Jones as *M. atavus*.

Monog. tenuis differs from *M. atavus* mainly in the characters of the thecæ, which are more elaborate than those of *M. atavus*, in which there is no sudden

expansion in the apertural region and hence no denticle or appearance of retroversion of the apertural margin.

Horizon and Localities.—Llandovery (zone of *M. Sedgwickii*).

Ireland: Limehill, Co. Tyrone. *S. Scotland:* Dobb's Linn; Belcraig Burn, etc. *Lake District:* Long Sleddale; Skelgill. *Wales:* Pary's Mountain, Anglesea; Quarry near River Twymyn, Llanbrynmair; E.S.E. Fuches Gau Farm House, Pont Erwyd, etc.

Associates, etc.—*Monog. tenuis* occurs in some abundance in the *M. Sedgwickii* zone, in which it often characterises a distinct band or sub-zone (Lake District and C. Wales). It is commonly associated with *Monog. Sedgwickii*, *M. limatulus*, *M. argenteus* var. *cygneus*, *Glyptog. serratus*, and *Climacog. scalaris*, etc.

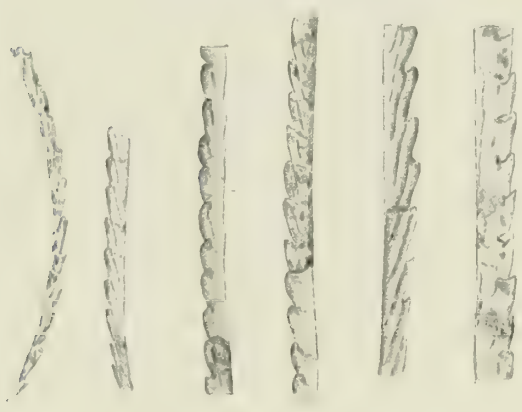
Collections.—Geological Survey of Scotland, Geological Survey of England and Wales, British Museum (Natural History), Sedgwick Museum, Greenly, Jones, Lapworth, and the Authors.

Monograptus argutus, Lapworth. Plate XL, figs. 3 *a—e*.

1876. *Monograptus argutus*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 318, pl. x, figs. 13 *a—c*.

Polypary several cm. in length, arcuate distally, and involute proximally, widening steadily to a maximum breadth of 1·5 mm. Thecæ eight in 10 mm., with conspicuous sigmoid curvature of their walls, overlapping fully one-half their length, and with introverted and slightly introtorted apertural margins opening within pouch-shaped excavations.

FIGS. 274 *a—f*.—*Monograptus argutus*, Lapworth.



a *b* *c* *d* *e* *f*

a. Proximal portion, showing dorsal curvature. Enlargement of part of Pl. XL, fig. 3 *b*.
b. Portion near proximal end; preserved mainly as a cast. Skelgill; Stockdale Shales. Coll. Lapworth.
c and *d*. Portions of same specimen, showing the different appearances presented by the thecæ. Parts of specimen on same slab as fig. 274 *b*.
e. Adult thecæ; preserved partly as a cast, partly in relief. Enlargement of part of Pl. XL, fig. 3 *e*.
f. Adult thecæ, compressed. Another part of specimen fig. 274 *e*.

Description.—The polypary is slender and several cm. in length; it is fairly robust in the initial portion, and the increase in width takes place wholly within the first few cm. of length, so that distal fragments have a uniform breadth.

The thecæ do not exceed 3 mm. in length; in their general characters—namely, the pronounced sigmoid curvature of their walls and the introversion and introtorsion of the apertural margin—

they show a decided approach to the type regarded as characteristic of the genus *Dicellograptus*.

Affinities.—In the form of the polypary *Monog. argutus* comes, perhaps, nearest to *M. revolutus*, but the characters of the thecæ are distinct and, indeed, unique amongst the *Monograpti*.

Horizon and Localities.—Llandovery (Birkhill Shales), top of zone of *M. gregarius*.

S. Scotland: Dobb's Linn. *Wales:* Old Quarry 270 yards N.E. Gwen-ffrwd Uchaf Farm House, Pont Erwyd, etc. *Lake District:* Skelgill.

Associates, etc.—*Monog. argutus* is a fairly abundant fossil in the Upper Birkhill Shales, immediately below the zone of *M. convolutus*, at a horizon corresponding with the *M. argenteus* band of the Lake District and the *M. leptotheca* band of the Pont Erwyd locality. It occurs associated with *Monog. leptotheca*, *M. Clingani*, *M. communis*, and other forms.

Collections.—Sedgwick Museum, Geological Survey of England and Wales, Jones, Lapworth, and the Authors.

Group III.

Monograpti in which the mature thecæ are short tubes with abrupt sigmoid curvature and some torsion of the thecal axis, so that the apertural margins show occasionally within distinct excavations in the ventral margins.

The thecæ in this group show an approach in character to those of the *M. priodon* type, but the apertural region is adnate instead of isolate and the torsion of the thecal axis is but slight. There is often an appearance of narrowing towards the apertural margin, but this is largely, if not entirely, induced by the torsion of the thecal axis. As a result of this torsion the polypary viewed in the one aspect shows thecæ resembling those of *M. dubius*, while in the other they resemble those of *Climacograptus*. The polyparies are approximately straight or slightly flexed.

Monograptus vomerinus (Nicholson). Plate XLI, figs. 1 *a*—*e*.

1850. *Graptolithus colonus*, Barrande, Grapt. de Bohême, pl. ii, fig. 4.
1851. *Graptolithus colonus*, Suess, Böhmische Graptolithen, pl. viii, figs. *a*—*f*.
1868. *Graptolites priodon*, Nicholson, Quart. Journ. Geol. Soc., vol. xxiv, pl. xx, figs. 7, 8.
1872. *Graptolites vomerinus*, Nicholson, Monog. Brit. Grapt., p. 53, fig. 21.
1876. *Monograptus vomerinus*, Lapworth, Geol. Mag., dec. ii, vol. iii, p. 353, pl. xii, figs. 6 *a*—*e*.
1900. *Monograptus vomerinus*, var. *a*, Elles, Quart. Journ. Geol. Soc., vol. lvi, p. 403.

Polypary 1—8 cm. in length, approximately straight, or slightly flexed at the proximal extremity, widening rapidly from an initial breadth of ·4 mm. to a maximum of about 2 mm. within a short distance of the proximal end.

Sicula conspicuous. Thecæ short, eleven to ten in 10 mm. with slight ogee-form curvature, overlapping about one-half their length, and having their apertural margins either everted or appearing in distinct excavations.

Description.—The polypary varies very much in size, but all fragments of the initial portion show the characteristic rapid widening, the maximum breadth being attained within 2·5 cm. of the proximal end.

The conspicuous sicula has a length of fully 1·5 mm. and reaches well above the level of the aperture of th. 1; its outer wall is slightly curved, but the inner continues the straight line of the dorsal wall of the polypary.

Figs. 275 *a—f.*—*Monograptus vomerinus*, Nicholson.

a *b* *c* *d* *e* *f*

a. Proximal end, showing sicula; preserved as a cast. Ruthin Road, nr. Llangollen; Wenlock Shales (zone of *Cyrtog. Murchisoni*). Coll. Elles.

b. Proximal end, showing sicula, preserved in relief. Lledcwm Stream, Newydd Fynyddog, nr. Llanbrynmair; Wenlock Shales. Coll. Wood.

c. Thecæ near proximal end; in full relief, showing torsion of thecal axis. Ibid.

d. Adult thecæ. seen partly from the back so that the apertures are concealed. Enlargement of part of Pl. XLI, fig. 1 *e*.

e. Adult thecæ with apertures facing the observer. Reverse side of Fig. 275 *d*.

f. Adult thecæ as they usually appear in a compressed specimen. Pencerrig, nr. Builth; Wenlock Shales (zone of *Cyrtog. Murchisoni*). Coll. Elles.

All the thecæ are short, the distal ones having a length of only 1·5 mm. and the proximal ones are much shorter with the exception of th. 1, which has a length of 1 mm. The thecæ present various appearances according to the different conditions of preservation. Sometimes they seem to have abrupt sigmoid curvature and the apertural margins are situated within distinct excavations occupying about one-third of the total breadth of the polypary (Fig. 275 *f*). This is their most characteristic aspect. The thecæ of specimens preserved in relief, however, show a tendency to the ogee curvature characteristic of *M. priodon* (Fig. 275 *c*), and in this case their apertures are either very conspicuous (Fig. 275 *c*) or wholly concealed (Fig. 275 *d*).

In the most characteristic view the thecæ obviously recall those of *Climacograptus*, but it is clear that the thecæ cannot have been quite so simple in form, and there must have been some torsion of the axis of the thecæ in order to account for the different appearances after compression (Figs. 275 *a—f*).

Affinities.—*Monog. vomerinus* is very closely related to all its varieties, and from most of them it is indistinguishable in the distal portion. The proximal ends are, however, distinct, and in var. *crenulatus* the thecal apertures are narrower than in the typical form, while in var. *basilicus* the polypary is altogether more robust.

Horizon and Localities.—Wenlock Shales (all zones).

Lake District: Southwaite Wood; Austwick Beck; W. side Long Sleddale, etc. *Wales:* Benarth Shore, Conway; Rose Mill Farm, Conway; Pencerrig; Trecoed, near Builth; R. Irfon, near Builth; Corwen; Ruthin Road, nr. Llangollen; Tarannon District. *Scotland:* Riccarton.

Associates, etc.—*Monog. vomerinus* is a common fossil throughout the Wenlock Shales; it seems to make its first appearance in their passage beds below, but is especially abundant in the Lower Wenlock Beds, where it occurs associated with *Cyrtog. Murchisoni*, *Monog. priodon*, *Gladiog. Geinitzianus*, and other forms. At higher horizons it may be found with any of the zone fossils, and with *M. Flemingii* and *M. dubius*.

FIGS. 276 *a* and *b*.—*Monograptus vomerinus*, var. *basilicus* (Lapworth).

a *b*

a. Proximal end. Enlargement of part of Pl. XLI, fig. 2 *d*.

b. Adult thecæ, showing different appearances presented according to varying compression. Enlargement of part of Pl. XLI, fig. 2 *c*.

Collections.—Sedgwick Museum, Lapworth, and the Authors, etc.

Var. **basilicus,** Lapworth. Plate XLI, figs. 2 *a*—*d*.

1880. *Monograptus galaensis* var. *basilicus*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 152, pl. iv, figs. 6 *a*, 6 *b*.

In var. *basilicus* the polypary is far stouter than in *M. vomerinus*, attaining a breadth of at least 3 mm., and occasionally even more. The thecæ are very similar in form to those of *M. vomerinus*, but overlap for fully two-thirds of their length.

Horizon and Localities.—Wenlock Shales (zones of *Cyrtog. Murchisoni* to *Cyrtog. Linnarssoni*).

Wales: Pencerrig, Builth, Builth Road, etc.

Var. *basilicus* is fairly common in the Lower Wenlock Shales of the Builth area, where it occurs associated with *Cyrtog. Murchisoni*, *Monog. priodon*, *M. vomerinus*, *M. riccartonensis*, *Cyrtog. Linnarssoni*, and other forms.

Collections.—Lapworth and the Authors.

Var. **gracilis,** var. nov. Plate XLI, figs. 3 *a*—*d*.

1900. *Monograptus vomerinus*, var. *β*., Elles, Quart. Journ. Geol. Soc., p. 405, fig. 16.

Var. *gracilis* differs from *M. vomerinus* in having the whole proximal portion gracefully recurved; the polypary also widens more gradually, and its width rarely

Fig. 277.—*Monograptus vomerinus*, var. *gracilis*, nov.

Proximal end, showing sicula. Castle Crab, nr. Builth; Wenlock Shales. Coll. Elles.

exceeds 1·6 mm., while the sicula is short, measuring 1·2 mm. in length. The thecæ number thirteen in 10 mm.

Horizon and Localities.—Wenlock Shales (zone of *Cyrtog. Murchisoni*).

Wales: Pencerrig, near Builth. *Scotland:* Riccarton.

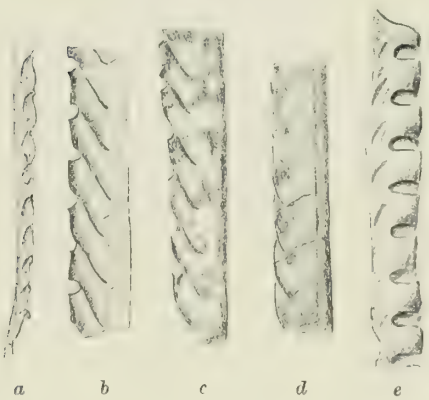
Associates, etc.—So far as our present knowledge extends var. *gracilis* is confined to the basal zone of the Wenlock Shales.

Collections.—Lapworth and the Authors.

Var. **crenulatus** (Törnquist). Plate XLI, figs. 4 *a—d*.

1881. *Monograptus crenulatus*, Törnquist, Geol. Fören. Förhandl., Bd. v, p. 438, pl. 17, fig. 4.
1892. *Monograptus crenulatus*, Törnquist, Siljansområdets Graptol., ii, p. 11, pl. i, figs. 12—16.
1900. *Monograptus vomerinus*, var. γ, Elles, Quart. Journ. Geol. Soc., vol. lvi, p. 405, fig. 15.

Figs. 278 *a—e*.—*Monograptus vomerinus*, var. *crenulatus* (Törnquist).



a *b* *c* *d* *e*

a. Proximal end, showing sicula. Tarannon River, near Dolgau Farm; Dolgau Beds. Coll. Wood.
b. Adult thecæ; in relief. Enlargement of part of Pl. XLI, fig. 4 *b*.
c. Adult thecæ; preserved as a cast. Part of same specimen as Fig. 278 *b*.
d. Adult thecæ; preserved so that apertures are concealed. Enlargement of part of specimen on same slab as Figs. 278 *b* and *c*.
e. Specimen in relief, showing thecal apertures. Enlargement of part of Pl. XLI, fig. 4 *c*.

In addition to the varieties of *Monog. vomerinus* enumerated above, there occurs at the top of the Tarannon Shales and ranging thence into the lowest Wenlock Beds, a characteristic variety which is certainly their forerunner; this has been regarded as a distinct species, but it is best considered as a variant of the typical *M. vomerinus*, in which the thecæ are more closely set in the proximal portion (thirteen to ten in 10 mm.), and the apertural excavation is smaller (one-fifth the total breadth of the polypary). The proximal end is practically straight; the sicula has a length of 1·5 mm., but unlike that of the typical form the first theca is so short that the apex of the sicula reaches to the level of the aperture of th. 2.

Horizon and Localities.—Gala-Tarannon (zone of *M. crenulatus*).

Wales: Benarth Wall, Conway; Neckarmount Road, Conway; Tarannon River; Afon Iaen, between Dolfach and bridge below Pen-y-graig, Llanbrynmair; Plasbach Stream, Llanbrynmair; stream east of Lledcwm, Llanbrynmair, etc.

Associates, etc.—Var. *crenulatus* is commonly found with *Monog. priodon* and *M. subconicus*.

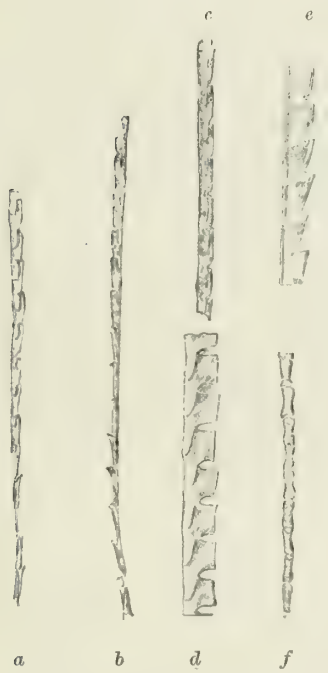
Collections.—Lapworth and the Authors.

Monograptus griestoniensis (Nicol). Plate XLI, figs. 5 *a*—*d*.

1850. *Graptolites griestoniensis*, Nicol, Quart. Journ. Geol. Soc., vol. vi, p. 63, fig. 2.

Polypary several cm. in length, slightly flexuous, widening from a very slender proximal extremity to a maximum diameter of ·7 mm. Thecæ ten in 10 mm., with abrupt sigmoid curvature and horizontal apertural margins, situated in distinct excavations occupying fully one-third of the total breadth of the polypary.

FIGS. 279 *a*—*f*.—*Monograptus griestoniensis*, Nicol.



a. Proximal end, showing sicula. Tarannon River, below Dolgau Farm; Talerddig Grits. Coll. Wood.
b. Proximal end. Enlargement of part of specimen on same slab as Pl. XLI, fig. 5 *d*.
c. Distal thecæ; compressed. Enlargement of specimen on same slab as Pl. XLI, fig. 5 *c*.
d. Distal thecæ; in relief. Afon Cwm Calch, nr. Talerddig; Talerddig Grits. Coll. Wood.
e. Distal thecæ; compressed. Ibid.
f. Thecæ preserved with the dorsal side uppermost, giving characteristic "vertebræ-like" appearance. Same locality as Fig. 279 *a*. Coll. Wood.

Description.—The polypary is commonly somewhat curved, having the thecæ on the concave margin; there is, however, some variation in the amount of curvature in the specimens from different localities. Most of those from Grieston Quarry are conspicuously flexuous, while those from the Rhayader country tend to be less curved, and those from the Tarannon district are, as a rule, so little curved that fragments appear almost straight and rigid; there would appear to be, however, all degrees of curvature between the extreme types. The polypary is extremely slender near the proximal end, not exceeding ·2 mm. in width, and the breadth increases very gradually until the maximum of ·7 mm. is attained.

The sicula is fairly conspicuous, measuring ·6 mm. in length and reaching nearly to the level of the aperture of th. 1.

The thecæ in the maturer parts of the polypary have a length of fully 2 mm.; they overlap one-half their length or rather less, and the apertural excavations are conspicuous, especially in sub-scalariform views. A characteristic aspect presented by the polypary is that in which the apertures are entirely concealed and the stipe has the appearance of a series of vertebræ (Fig. 279 *f*).

Affinities.—The extreme tenuity of the polypary and the character of the

thecæ render *Monog. griestoniensis* a very distinct form amongst British Graptolites.

Figs. 280 *a* and *b*.—*Monograptus* cf. *griestoniensis*, Nicol.

a. Portions near proximal end in relief. Enlargement of parts of Pl. XLI, fig. 6 *a*.
b. Distal thecæ. Another part of same specimen.

Horizon and Localities.—Gala-Tarannon (zone of *M. griestoniensis*).

S. Scotland: Grieston Quarry, near Innerleithen. *Wales:* Rhayader; Talerddig Railway Cutting; Afon Cwm Calch, near Talerddig; Tarannon River, etc.

Associates, etc.—*Monog. griestoniensis* is a characteristic fossil in the Tarannon Shales at a special horizon, where it occurs associated with *Monog. Marri*, *M. discus*, *M. priodon*, *M. nudus*, and *M. subconicus*.

Collections.—Sedgwick Museum, Geological Survey of England and Wales, Lapworth, and the Authors.

Note.—In the Tarannon District there occurs a form which is intermediate in character between *Monog. griestoniensis* and *M. vomerinus* var. *crenulatus* (Plate XLI, figs. 6 *a* and *b*). It is more rigid and widens more decidedly than does *M. griestoniensis*; at the same time it is distinctly more slender than the true var. *crenulatus*. It may possibly prove to be a distinct variety.

This form occurs typically near the top of the Talerddig Grits, not far below the zone of var. *crenulatus*.

Figs. 281 *a*—*e*.—*Monograptus crenularis*, Lapworth.

a. Proximal end, showing the lobate appearance of the thecæ. Enlargement of part of Pl. XLI, fig. 7 *d*.
b. Similar specimen. Enlargement of part of specimen on same slab as Fig. 281 *a*.
c. Adult thecæ; preserved as a slight impression. Enlargement of part of Pl. XLI, fig. 7 *b*.
d. Thecæ; preserved partly in relief, partly as a cast. Enlargement of part of Pl. XLI, fig. 7 *c*.
e. Thecæ; compressed. Part of specimen on same slab as Fig. 281 *c*.

Monograptus crenularis, Lapworth. Plate XLI, figs. 7 *a*—*e*.

1880. *Monograptus crenularis*, Lapworth, Ann. Mag. Nat. Hist. [5], vol. v, p. 153, pl. iv, figs. 10 *a*—10 *c*.

Polypary long and slightly arcuate throughout, widening very gradually from ·5 mm. to a maximum breadth of 1 mm. Thecæ twelve to ten in 10 mm., overlapping two thirds their length, with slightly everted apertural margins, appearing occasionally within distinct excavations.

Description.—The polypary is characteristically slender, and the maximum breadth is attained some distance from the proximal end.

PLATE XXXVI.

Genus **Monograptus,** Geinitz.

Note.—The figures on Plates XXXVI—XLI (which should be studied with a hand lens) are approximately natural size, but there are slight variations.

Figs.

1 *a—e.*—*Monograptus cyphus*, Lapworth. (Page 362.)

1 *a*. Typical specimen, showing sicula. Dobb's Linn, S. Scotland. Lower Birkhill Shales. Lapworth's Collection.

1 *b*. Incomplete specimen, broadly recurved. Waterfall, Long Burn, Dobb's Linn. Lower Birkhill Shales. Lapworth's Collection.

1 *c*. Incomplete specimen, preserved in relief. Dobb's Linn. Birkhill Shales. Sedgwick Museum.

1 *d*. Specimen, with abrupt curvature of the proximal portion. Dobb's Linn. Lower Birkhill Shales. Lapworth's Collection.

1 *e*. Incomplete, but long specimen, (?) figured Lapworth, Geol. Mag., 1876, pl. xii, fig. 3 *a*. Ibid.

2 *a—e.*—*Monograptus acinaces*, Törnquist. (Page 364.)

2 *a*. Median fragment, in relief, figured Jones (as *M. rheidolensis*), Quart. Journ. Geol. Soc., vol. lxv, p. 534, fig. 19 *a*. Rheidol Gorge, Pont Erwyd, Cardiganshire. Rheidol Group. Geological Survey of England and Wales, Jermyn Street (23708).

2 *b*. Reverse of above specimen, cast.

2 *c*. Fragment of proximal end. Nant Fuches-wen, Pont Erwyd. Rheidol Group. Jones' Collection.

2 *d*. Distal fragment in relief, figured Jones (as *M. rheidolensis*), Quart. Journ. Geol. Soc., vol. lxv, p. 534, fig. 19 *c*. Rheidol Gorge. Geological Survey of England and Wales (23709).

3 *a—d.*—*Monograptus gregarius*, Lapworth. (Page 365.)

3 *a*. Part of the type slab, showing the gregarious habit of this species. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

3 *b*. Complete specimen on same slab as above.

3 *c*. Ibid.

3 *d*. Small specimen, in relief. Penwhapple Glen, Girvan. Llandovery Beds. Lapworth's Collection.

FIGS.

4 *a*—*d*.—*Monograptus bohemicus* (Barrande). (Page 367.)

4 *a*. Typical specimen, figured Wood, Quart. Journ. Geol. Soc., vol. lvi, pl. xxv, fig. 27 A. River Irfon, near Builth. Lower Ludlow Shales. Wood's Collection.

4 *b*. Specimen, showing sicula, figured Wood, loc. cit., fig. 27 B. Aberedw Hill, near Builth. Lower Ludlow Shales. Wood's Collection.

4 *c*. Long specimen, with slightly curved distal portion. Hospital Road, Builth. Lower Ludlow Shales. Sedgwick Museum.

4 *d*. Similar specimen. River Irfon, near Builth. Lower Ludlow Shales. Wood's Collection.

5 *a*—*e*.—*Monograptus concinnus*, Lapworth. (Page 368.)

5 *a*. Two specimens crossing each other, figured Lapworth, Geol. Mag., 1876, pl. xi, fig. 1 *c*. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

5 *b*. Two similar specimens, one showing marked ventral curvature. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

5 *c*. Median fragment, part in relief, part impression. Waterfall, Dobb's Linn. Birkhill Shales. Lapworth's Collection.

5 *d*. More proximal fragment, mainly in relief. Rheidol Gorge, 400 yards E.S.E. of Bryn-chwîth Farm, Pont Erwyd. Geological Survey of England and Wales.

5 *e*. More distal fragment with marked curvature. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

5 *f*. Very broad distal fragment of great length, partly in relief, provisionally referred to this species (the complete specimen is twice this length). Rheidol Gorge, 420 yards E.S.E. of Bryn-chwîth Farm, Pont Erwyd. Rheidol Group. Geological Survey of England and Wales.

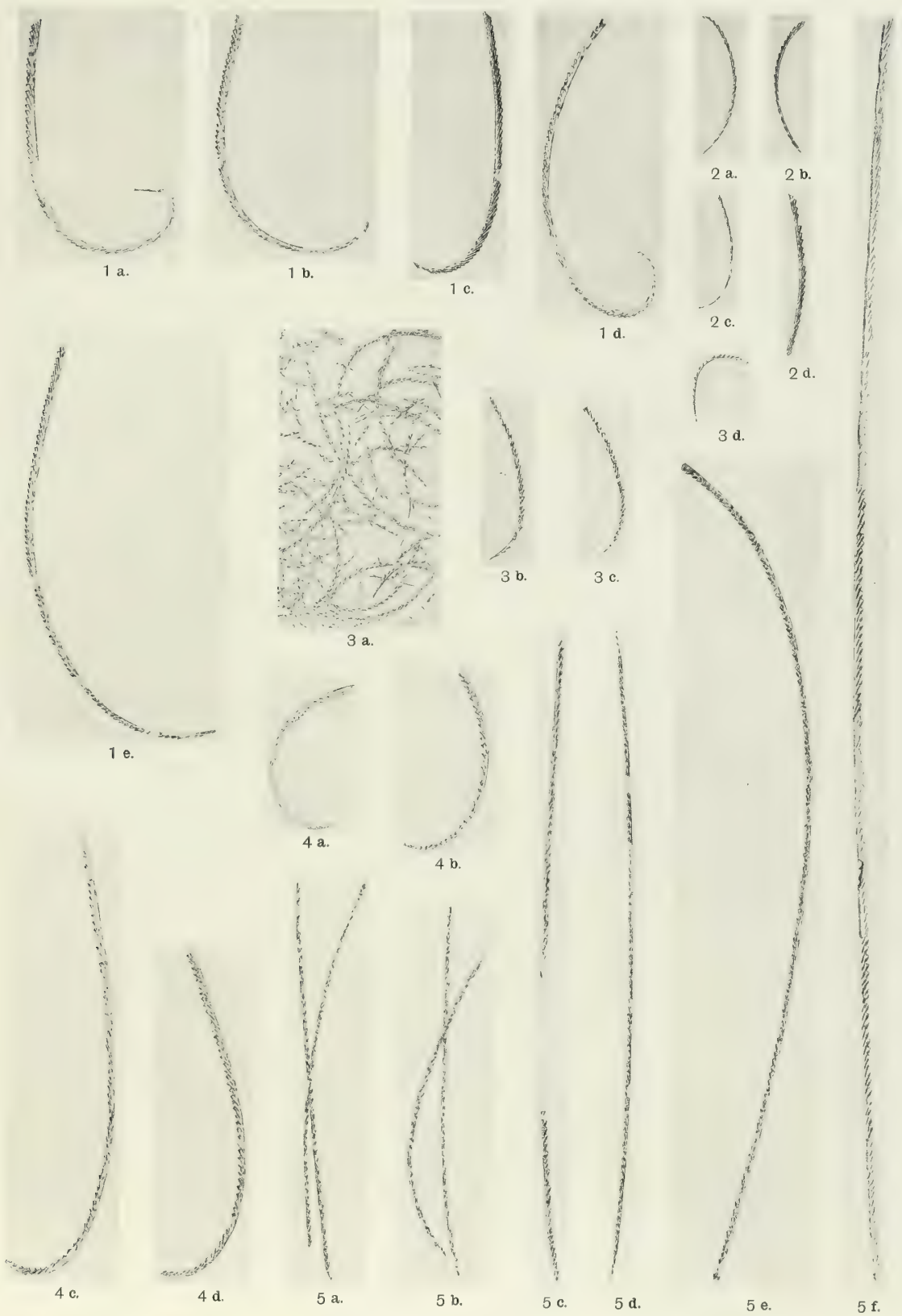


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PLATE XXXVII.

Monograptus—*continued.*

FIGS.

1 *a—e.*—*Monograptus Nilssoni* (Barrande). (Page 369.)

1 *a*. Typical specimen, figured Wood, Quart. Journ. Geol. Soc., vol. lvi, pl. xxv, fig. 28 A. Adferton, near Ludlow. Lower Ludlow Shales. Hopkinson's Collection.

1 *b*. Specimen, showing double curvature. Montgomery Road. Lower Ludlow Shales. Sedgwick Museum.

1 *c*. Broad distal fragment, figured Wood, loc. cit., fig. 28 B. Elton-Evenhay Lane, near Ludlow. Lower Ludlow Shales. Wood's Collection.

1 *d*. Long distal fragment. Trefnant Brook, Long Mountain. Lower Ludlow Shales. Wood's Collection.

1 *e*. Fairly complete specimen, with abrupt proximal curvature. Ibid.

2 *a—d.*—*Monograptus leptotheca*, Lapworth. (Page 371.)

2 *a*. Typical median fragment, internal cast in iron pyrites. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

2 *b*. Proximal fragment, partly in relief. Llanystwmdwy, near Criccieth. Llandovery Beds. Fearnsides Collection.

2 *c*. Distal fragment, with slight dorsal curvature. Rheidol Gorge, 440 yards S.S.E. of Bryn-chwîth Farm, Pont Erwyd. Castell Group (base of zone of *M. convolutus*). Geological Survey of England and Wales.

2 *d*. Long and broad distal fragment. Pary's Mountain, Anglesea. Llandovery Beds. Greenly's Collection.

3 *a—d.*—*Monograptus regularis*, Törnquist. (Page 372.)

3 *a*. Long distal fragment, impression. Dobb's Linn. Birkhill Shales. Geological Survey of Scotland, Edinburgh.

3 *b*. Distal fragment, mainly in relief. E. side of old quarry, N.E. of Fagwr-fawr Farm, 2 miles E.N.E. of Pont Erwyd. Castell Group (zone of *M. convolutus*). Geological Survey of England and Wales.

3 *c*. Fragment nearer proximal end, impression. Pary's Mountain, Anglesea. Llandovery Beds. Greenly's Collection.

3 *d*. Long fragment, cast. Rheidol Gorge, 420 yards E.S.E. of Bryn-chwîth Farm, Pont Erwyd. Rheidol Group. Geological Survey of England and Wales.

4 *a—d.*—*Monograptus jaculum* (Lapworth). (Page 373.)

4 *a*. Proximal portion. Dobb's Linn. Upper Birkhill Shales. Lapworth's Collection.

4 *b*. Distal portion, impression. Ibid.

4 *c*. Long distal fragment, with slight dorsal curvature, impression. Garple Linn, near Moffat. Upper Birkhill Shales. Lapworth's Collection.

4 *d*. Specimen on same slab as fig. 4 *c*.

5 *a, b.*—*Monograptus variabilis* (Perner). (Page 374.)

5 *a*. Proximal portion, showing sicula. Marsh, Conway. Tarannon Shales. Elles' Collection.

5 *b*. Distal fragment. Corner near Forge, Conway. Tarannon Shales. Elles' Collection.

6 *a—e.*—*Monograptus nudus* (Lapworth). (Page 375.)

6 *a*. Incomplete but typical specimen, figured Lapworth, Geol. Mag., 1876, pl. xii, fig. 1 *a*. Grieston Quarry, Innerleithen. Tarannon Shales. Lapworth's Collection.

6 *b*. Proximal portion, showing sicula. W. side of upper quarry, 550 yards E.S.E. of Fuches-gau Farm-house, Pont Erwyd. Castell Group. Geological Survey of England and Wales.

6 *c*. Similar specimen, impression. Nant Fuches-wen, Cardiganshire. Castell Group. Jones' Collection.

6 *d*. Distal fragment, partly in low relief. Same locality as fig. 6 *b*.

6 *e*. Proximal portion. Gelli Stream, Newydd Fynyddog, near Llanbrynmair. Tarannon Beds. Wood's Collection.

PLATE XXXVII—*continued.*

FIGS.

7 *a*—*d*.—*Monograptus dubius* (Suess). (Page 376.)

7 *a*. Rather broad specimen figured Wood, Quart. Journ. Geol. Soc., vol. lvi, pl. xxv, fig. 1 A. Elton Lane, near Ludlow. Lower Ludlow Shales. Hopkinson's Collection.

7 *b*. Typical specimen, showing sicula, figured Wood, loc. cit., fig. 1 B. Stormer Hall, near Leintwardine. Lower Ludlow Shales. Hopkinson's Collection.

7 *c*. Small specimen. Llwynrhedith Quarry, Long Mountain. Upper Wenlock Shales. Elles' Collection.

7 *d*. Very long, narrow specimen. Montgomery Road. Lower Ludlow Shales (zone of *M. Nilssoni*). Wood's Collection.

8. *Monograptus* cf. *gotlandicus*, Perner. (Page 382.)

Specimen, showing sicula, figured Wood, loc. cit., fig. 7. Old Dingle Mill, Long Mountain. Lower Ludlow Shales. Watts' Collection.

9. *Monograptus comis*, Wood. (Page 381.)

Type specimen, figured Wood, loc. cit., fig. 8 A. Elton-Evenhay Lane, near Ludlow. Lower Ludlow Shales. Wood's Collection.

10 *a*—*e*.—*Monograptus vulgaris*, Wood. (Page 378.)

10 *a*. Type specimen, figured Wood, loc. cit., fig. 2. Trefnant-Middletown Brook, Long Mountain. Lower Ludlow Shales (zone of *M. vulgaris*). Wood's Collection.

10 *b*. Specimen, showing distal extremity, on same slab as fig. 10 *a*.

10 *c*. Incomplete specimen, figured Wood, loc. cit., fig. 3. Ibid.

10 *d*. Narrow specimen. Trefnant-Middletown Brook, Long Mountain. Wood's Collection.

10 *e*. Similar specimen. Ibid.

11.—*Monograptus vulgaris*, var. *curtus*, Elles and Wood, nom. nov. (Page 379.)

Type specimen, figured Wood, loc. cit., fig. 4. Lane Farm, Long Mountain. Lower Ludlow Shales. Wood's Collection.

12 *a*—*d*.—*Monograptus tumescens*, Wood. (Page 379.)

12 *a*. Type specimen, figured Wood, loc. cit., fig. 5 A. Llettygynfach, Long Mountain. Lower Ludlow Shales (zone of *M. tumescens*). Wood's Collection.

12 *b*. Co-type specimen, fig. 5 B. Gorsty Farm, Elton-Ludlow Road. Ibid.

12 *c*. Broad specimen. Same locality as fig. 12 *a*.

12 *d*. Specimen on same slab as fig. 12 *c*.

13 *a*—*c*.—*Monograptus tumescens*, var. *minor* (McCoy). (Page 381.)

13 *a*. Typical specimen, figured Wood, loc. cit., fig. 6 A. Gorsty Farm, Elton-Ludlow Road, Lower Ludlow Shales (zone of *M. tumescens*). Wood's Collection.

13 *b*. Ibid., fig. 6 B.

13 *c*. Narrower specimen. Elton-Ludlow Road. Lower Ludlow Shales. Sedgwick Museum.

14 *a*—*d*.—*Monograptus* cf. *ultimus*, Perner. (Page 383.)

14 *a*. Typical specimen, figured Wood, loc. cit., fig. 9 A. Road between Co. Bridge and Ucheldre, near Frochas, Long Mountain. Lower Ludlow Shales (zone of *M. leintwardinensis*). Watts' Collection.

14 *b*. Proximal portion, showing sicula. Ibid.

14 *c*. Specimen on same slab as fig. 14 *b*.

14 *d*. Rather broader specimen. Ibid.

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Monograptus—*continued.*

FIGS.

1 *a—e.*—*Monograptus revolutus*, Kurck. (Page 384.)

1 *a*. Typical specimen, impression. Garple Linn, near Moffat. Lower Birkhill Shales. Geological Survey of Scotland, Edinburgh.

1 *b*. Less complete specimen. Dobb's Linn. Birkhill Shales (zone of *M. cyphus*). Wood's Collection.

1 *c*. Proximal portion. Garple Linn, near Moffat. Lower Birkhill Shales. Geological Survey of Scotland, Edinburgh.

1 *d*. Specimen in relief. Rheidol Gorge, 235 yards S. of Bryn-chwîth Farm-house, Pont Erwyd. Rheidol Group. Geological Survey of England and Wales.

1 *e*. Broad specimen (?). Lateral Gorge, Dobb's Linn. Birkhill Shales (zone of *M. cyphus*). Lapworth's Collection.

2 *a—c.*—*Monograptus revolutus*, var. *austerus*, Törnquist. (Page 385.)

2 *a*. Typical specimen. Long Cliff, Dobb's Linn. Birkhill Shales (zone of *M. cyphus*). Wood's Collection.

2 *b*. Proximal portion. Dobb's Linn. Birkhill Shales. Elles' Collection.

2 *c*. Proximal fragment. Coalpit Bay, Donaghadee, Co. Down. Llandovery Beds. Elles' Collection.

3 *a, b.*—*Monograptus revolutus*, var. *præcursor*, Elles and Wood, var nov. (Page 386.)

3 *a*. Type specimen, in full relief. Rheidol Gorge, 420 yards E.S.E. of Bryn-chwîth Farm, Pont Erwyd. Rheidol Group. Geological Survey of England and Wales.

3 *b*. Incomplete specimen, doubtfully referred to this form. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

4 *a –d.*—*Monograptus difformis*, Törnquist. (Page 386.)

4 *a*. Fairly complete specimen, in relief. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

4 *b*. Smaller specimen. Dobb's Linn ?. Birkhill Shales. Lapworth's Collection.

4 *c*. Characteristic specimen. Rheidol Gorge, S. of Bryn-chwîth Farm, Pont Erwyd. Rheidol Group. Jones' Collection.

4 *d*. Broader specimen, doubtfully referred to this species. River Twymyn, near Llanbrynmair. Dolgadfan Beds. Wood's Collection.

5 *a—d.*—*Monograptus argenteus* (Nicholson). (Page 388.)

5 *a*. Specimen in full relief. Skelgill. Skelgill Beds (band of *M. argenteus*). Lapworth's Collection (presented by H. O. Nicholson).

5 *b*. Similar specimen, in part relief. Skelgill. Skelgill Beds. Sedgwick Museum (Marr's Collection).

5 *c*. Narrower specimen, showing more of proximal portion. Skelgill. Skelgill Beds. Lapworth's Collection.

5 *d*. Specimen, showing longer proximal portion. Ibid.

FIGS.

6 *a—d.*—*Monograptus argenteus*, var. *cygneus* (Törnquist). (Page 389.)

6 *a*. Small specimen. Pary's Mountain, Anglesea. Llandovery Beds. Sedgwick Museum.

6 *b*. Specimen showing characteristic form, but badly preserved. Ibid.

6 *c*. Long distal fragment. Ibid.

6 *d*. Specimen distorted so as to resemble *M. limatulus*. Skelgill. Skelgill Beds. British Museum (Natural History), S. Kensington.

7 *a—d.*—*Monograptus limatulus*, Törnquist. (Page 390.)

7 *a*. Typical specimen. Grennan Point, N.W. of Port Logan, Wigtownshire. Birkhill Shales. Geological Survey of Scotland, Edinburgh.

7 *b*. Incomplete specimen. Skelgill. Skelgill Beds. Elles' Collection.

7 *c*. Long specimen. Dobb's Linn. Birkhill Shales (zone of *M. convolutus*). Elles' Collection.

7 *d*. Specimen much distorted, but showing long, slender proximal portion. Same locality as fig. 7 *b*.

8 *a—d.*—*Monograptus colonus* (Barrande). (Page 391.)

8 *a*. Typical specimen, mainly in relief, figured Wood, Quart. Journ. Geol. Soc., vol. lvi, pl. xxv, fig. 10 B. Helm Knot, Lake District. Coniston Flags. British Museum (Natural History), S. Kensington.

8 *b*. Rather narrow specimen, showing recurved proximal thecæ. Vicarage Road, Builth. Lower Ludlow Shales. Sedgwick Museum.

8 *c*. Broad specimen, in low relief, figured Wood, loc. cit., fig. 10 D. Adferton, near Ludlow. Lower Ludlow Shales. Hopkinson's Collection.

8 *d*. Characteristic specimen, figured Wood, loc. cit., fig. 10 *c*. River Irfon, Builth. Lower Ludlow Shales. Wood's Collection.

9 *a—c.*—*Monograptus colonus* (?), var. *ludensis* (Murchison). (Page 394.)

9 *a*. Complete specimen, figured Wood, loc. cit., fig. 11. Llanfair, Montgomeryshire. Ludlow Beds. Dr. Humphreys' Collection, Llanfair.

9 *b*. Fairly complete specimen. Llanfair, Montgomeryshire. Ludlow Beds. Wood's Collection.

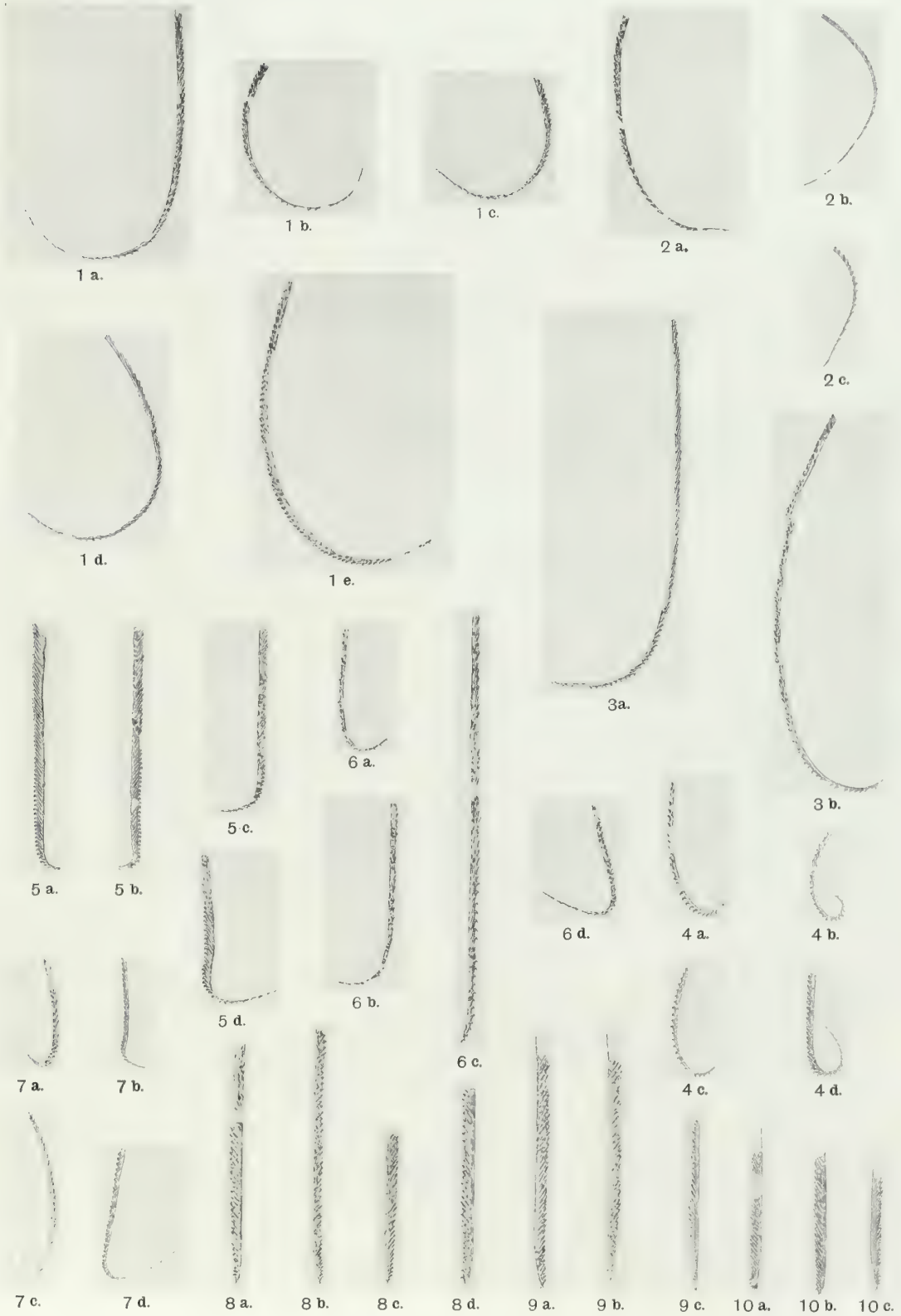
9 *c*. Narrower specimen, showing sicula. Ibid.

10 *a—c.*—*Monograptus colonus*, var. *compactus*, Wood. (Page 393.)

10 *a*. Type specimen (somewhat broken), figured Wood, loc. cit., fig. 12. Elton-Evenhay Lane, near Ludlow. Lower Ludlow Shales. Wood's Collection.

10 *b*. Well-preserved specimen. Stormer Hall, near Leintwardine. Lower Ludlow Shales. Wood's Collection.

10 *c*. Small specimen. Elton-Evenhay Lane. Lower Ludlow Shales. Sedgwick Museum.



MONOGRAPTUS.

PLATE XXXIX.

Monograptus—*continued.*

FIGS.

1 *a—d.*—*Monograptus atavus*, Jones. (Page 403.)

1 *a*. Proximal portion, figured Jones, Quart. Journ. Geol. Soc., vol. lxv, p. 532, fig. 18 *a*. Rheidol Gorge. Rheidol Group. Geological Survey of England and Wales (23706).

1 *b*. Straighter and more median fragment. Rheidol Gorge, 235 yards S. of Bryn-chwîth Farm, Pont Erwyd. Rheidol Group. Geological Survey of England and Wales.

1 *c*. Median fragment with dorsal curvature, figured Jones, loc. cit., fig. 18 *d*. Ibid. (23711).

1 *d*. Long fragment with ventral curvature. Same locality as fig. 1 *b*.

2 *a—d.*—*Monograptus Roemeri* (Barrande). (Page 397.)

2 *a*. Typical specimen, figured Wood, Quart. Journ. Geol. Soc., vol. lvi, pl. xxv, fig. 13 A. Trefnant-Middletown Brook, Long Mountain. Lower Ludlow Shales (zone of *M. scanicus*). Wood's Collection.

2 *b*. Distal fragment, figured Wood, loc. cit., fig. 13 B. Ibid.

2 *c*. Somewhat narrower specimen, in relief. Helm Knot, Dent. Coniston Grits. Sedgwick Museum.

2 *d*. Characteristic specimen, well preserved. Dudley. Ludlow Shales. University of Birmingham.

3 *a—d.*—*Monograptus chimæra* (Barrande). (Page 398.)

3 *a*. Typical specimen, figured Wood, loc. cit., fig. 18 B. Stream from Ucheldre to Trewern Bridge, Long Mountain. Watts' Collection.

3 *b*. Fairly complete specimen, figured Wood, loc. cit., fig. 18 A. Elton-Ludlow Road. Lower Ludlow Shales. Wood's Collection.

3 *c*. Proximal portion. Ibid., fig. 18 C.

3 *d*. Small specimen. Ibid., fig. 18 D.

4 *a—c*. *Monograptus chimæra*, var. *semispinosus*, Elles and Wood, nom. nov. (Page 401.)

4 *a*. Complete specimen. Stormer Hall, near Leintwardine. Lower Ludlow Shales. Wood's Collection.

4 *b*. Narrower specimen. Ibid.

4 *c*. Type specimen, figured Wood, loc. cit., fig. 20. Elton-Ludlow Road. Lower Ludlow Shales (zone of *M. scanicus*). Wood's Collection.

5 *a—d.*—*Monograptus chimæra*, var. *Salweyi* (Hopkinson). (Page 400.)

5 *a*. Complete specimen, figured Wood, loc. cit., fig. 19 A. Stormer Hall, near Leintwardine. Lower Ludlow Shales. Wood's Collection.

5 *b*. Type specimen, showing long virgula, figured Lapworth, Ann. Mag. Nat. Hist. [5], vol. v (1880), pl. iv, figs. 2 *a* and *b*. Stormer Hall. Lower Ludlow Shales. Hopkinson's Collection.

5 *c*. Narrow specimen, cast, showing thecal spines well. Stormer Hall. Lower Ludlow Shales. Wood's Collection.

5 *d*. Reverse of fig. 5 *c*, in relief, thecal spines very inconspicuous. Ibid.

6 *a—e.*—*Monograptus varians*, Wood. (Page 395.)

6 *a*. Type specimen, figured Wood, loc. cit., fig. 14 A. Old Dingle Mill, Long Mountain. Lower Ludlow Shales. Wood's Collection.

6 *b*. Broader specimen, figured Wood, loc. cit., fig. 14 B. Road above Garbett's Hall, Long Mountain. Lower Ludlow Shales. Wood's Collection.

PLATE XXXIX—*continued.*

FIGS.

6 *a—e.*—*Monograptus varians*, Wood (*continued*).

6 *c*. Distal portion, showing virgula. Loc. cit., fig. 16 A. Stormer Hall, near Leintwardine. Lower Ludlow Shales. Wood's Collection.

6 *d*. Complete specimen. Loc. cit., fig. 15. Elton Lane, near Ludlow. Lower Ludlow Shales. Wood's Collection.

6 *e*. Complete specimen, cast, figured Lapworth (as *M. colonus*), Ann. and Mag. Nat. Hist. [5], vol. v, pl. iv, figs. 3 *b* and 3 *d*, and Wood, loc. cit., fig. 16 B. Mary Knoll, near Ludlow. Lower Ludlow Shales. Hopkinson's Collection.

7 *a—e.*—*Monograptus varians*, var. *pumilus*, Wood. (Page 396.)

7 *a*. Type specimen, preserved so as to appear narrower than usual, figured Wood, loc. cit., fig. 17 B. Elton Lane, near Ludlow. Lower Ludlow Shales (zone of *M. scanicus*). Wood's Collection.

7 *b*. Co-type, somewhat wider, figured Wood, loc. cit., fig. 17 A. Ibid.

7 *c*. Small, but typical specimen. Elton Lane. Lower Ludlow Shales. Wood's Collection.

7 *d*. Specimen on same slab as fig. 7 *c*.

7 *e*. Complete specimen, on same slab as figs. 7 *c* and 7 *d*.

8 *a—f.*—*Monograptus leintwardinensis*, Hopkinson. (Page 401.)

8 *a*. Type specimen, figured Wood, loc. cit., fig. 21 A. Church Hill Quarry, near Leintwardine. Lower Ludlow Shales (zone of *M. leintwardinensis*). Hopkinson's Collection.

8 *b*. Co-type, figured Wood, loc. cit., fig. 21 B. Ibid.

8 *c*. Long narrow specimen. Church Hill Quarry, near Leintwardine. Lower Ludlow Shales. Fearnsides' Collection.

8 *d*. Broader specimen. On same slab as fig. 8 *c*.

8 *e*. Short, broad specimen. On same slab as figs. 8 *c* and *d*.

8 *f*. Characteristic specimen. On same slab as figs. 8 *c—e*.

9 *a—d.*—*Monograptus leintwardinensis*, var. *incipiens*, Wood. (Page 402.)

9 *a*. Type specimen, figured Wood, loc. cit., fig. 22 A. Montgomery Road, Lower Ludlow Shales. Wood's Collection.

9 *b*. Co-type, figured Wood, loc. cit., fig. 22 B. Long Mountain. Lower Ludlow Shales. Watts' Collection.

9 *c*. Short broad specimen. Same locality as fig. 9 *a*.

9 *d*. Very long specimen. On same slab as fig. 9 *b*.

10 *a—e.*—*Monograptus Sandersoni*, Lapworth. (Page 404.)

10 *a*. Median fragment. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

10 *b*. Proximal fragment, with strong ventral curvature, figured Lapworth, Geol. Mag., 1876, pl. xi, fig. 2 *e*. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

10 *c*. Distal fragment with conspicuous ventral curvature. Coalpit Bay, Donaghadee. Llandovery Beds. Sedgwick Museum.

10 *d*. Distal fragment, with only slight curvature, in low relief. East bank of road from Pont Erwyd to Devil's Bridge, 50 yards E.N.E. of Bryn-chwith Farm. Rheidol Group. Geological Survey of England and Wales.

10 *e*. Long distal fragment. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

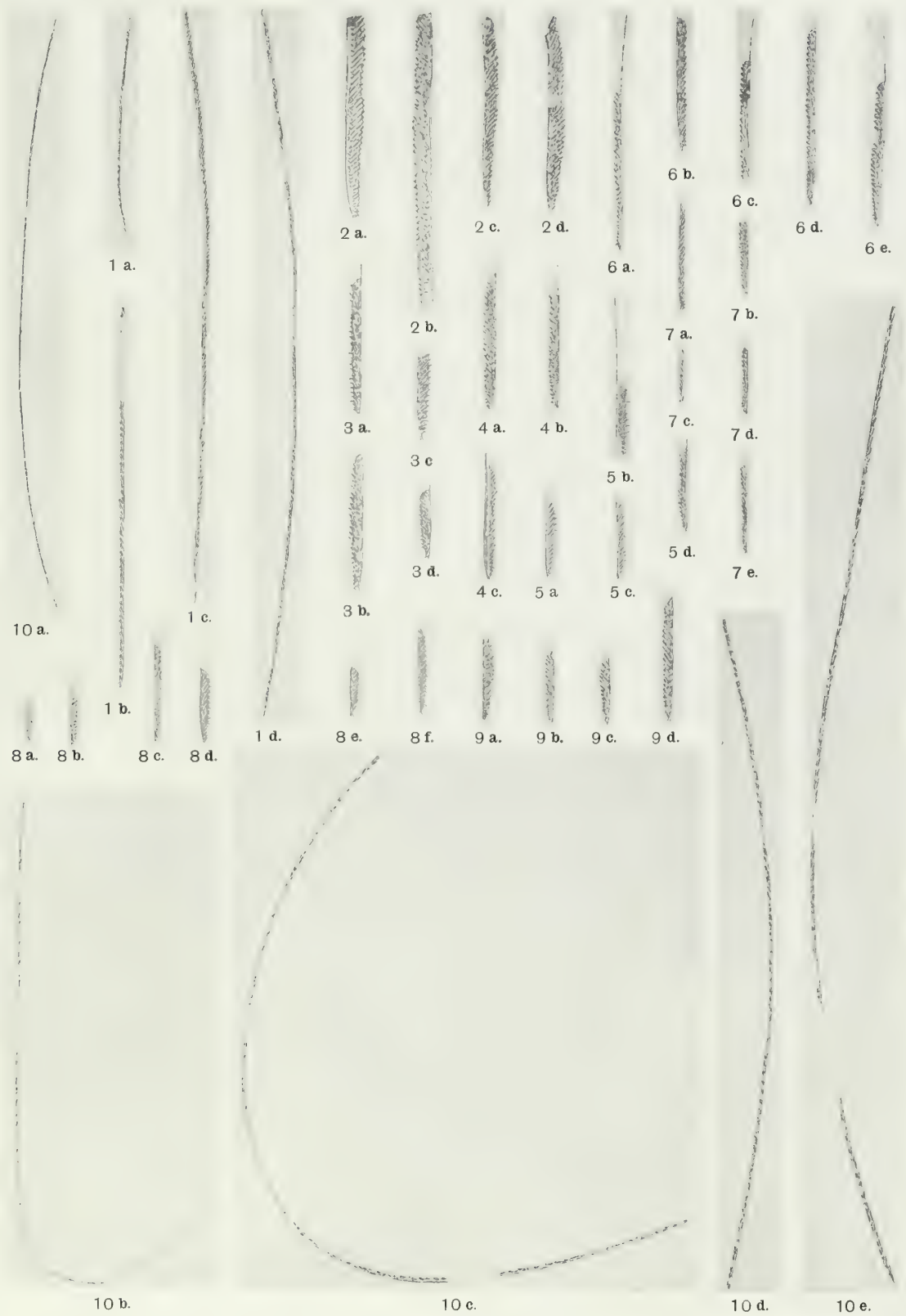


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PLATE XL.

Monograptus—*continued.*

Figs.

1 *a—e.*—*Monograptus incommodus*, Törnquist. (Page 406.)

1 *a*. Long distal fragment. Skelgill. Skelgill Beds (zone of *Dimorphog. confertus*). Sedgwick Museum.

1 *b*. Proximal fragment, showing characteristic double curvature. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

1 *c*. Distal fragment. Dobb's Linn. Birkhill Shales. Sedgwick Museum.

1 *d*. Small distal fragment, partly in relief. Rheidol Gorge. Rheidol Group. Geological Survey of England and Wales.

1 *e*. Median fragment. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

2 *a—e.*—*Monograptus tenuis* (Portlock). (Page 407.)

2 *a*. Specimen on Portlock's type slab, showing general form of polypary. Limehill, Co. Tyrone. Upper Llandovery Beds. Geological Survey of England and Wales.

2 *b*. More distal fragment. On same slab as fig. 2 *a*.

2 *c*. Small proximal fragment, cart track, 10 yards west of entrance to lower quarry, 550 yards E.S.E. of Fuches-gau Farm-house, Pont Erwyd. Castell Group. Geological Survey of England and Wales.

2 *d*. Distal fragment. On same slab as fig. 2 *c*.

2 *e*. Proximal portion, labelled by Nicholson as *Monograptus discretus*. Skelgill. Skelgill Beds. British Museum (Natural History), S. Kensington.

3 *a—e.*—*Monograptus argutus*, Lapworth. (Page 408.)

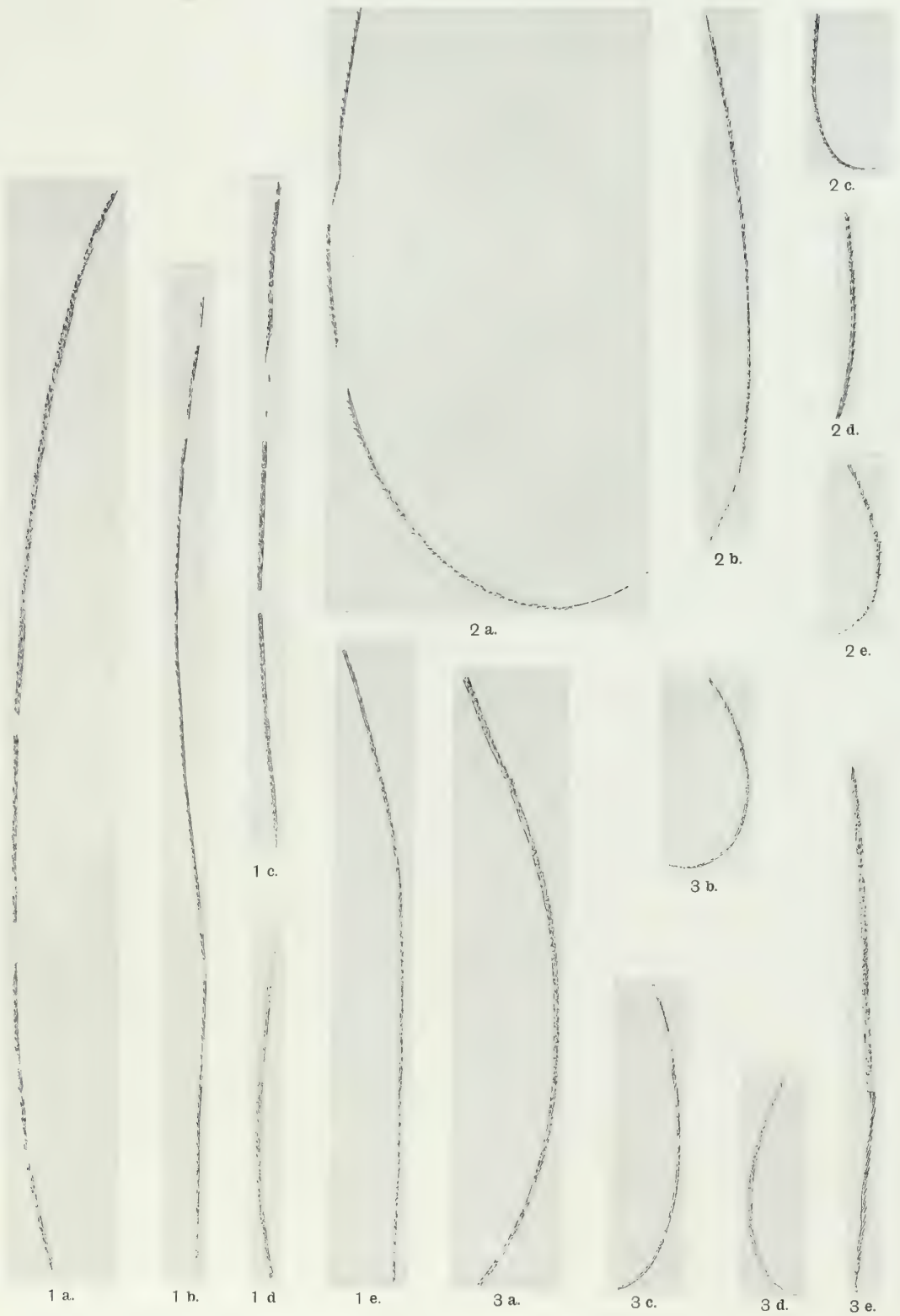
3 *a*. Type specimen, showing general form, partly figured Lapworth, Geol. Mag., 1876, pl. x, fig. 13 *b*. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

3 *b*. Proximal portion, showing curvature. S. side of old quarry, 270 yards N.E. of Gwen-ffrwd-uchaf Farm, Pont Erwyd. Base of zone of *M. convolutus*. Geological Survey of England and Wales.

3 *c*. Proximal portion, (?) figured Lapworth, loc. cit., fig. 13 *a*. Dobb's Linn. Birkhill Shales. Lapworth's Collection.

3 *d*. Proximal fragment. Rheidol Gorge, 440 yards S.S.E. of Brynchwîth Farm-house, Pont Erwyd. Base of zone of *M. convolutus*. Geological Survey of England and Wales.

3 *e*. Distal fragment, part in relief, part impression. On same slab as reverse side of fig. 3 *d*.



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Monograptus—*continued.*

Figs.

1 *a—e.*—*Monograptus vomerinus* (Nicholson). (Page 409.)

1 *a*. Typical specimen, impression, (?) figured Lapworth, Geol. Mag., 1876, pl. xii, fig. 6 *a*. Elliotsfield, S. Scotland. Riccarton Beds. Lapworth's Collection.

1 *b*. Smaller specimen, in full relief. Lledcwm Stream, Newydd Fynyddog, near Llanbrynmair. Wenlock Shales (zone of *Cyrtog. Murchisoni*). Wood's Collection.

1 *c*. Specimen, partly in relief, part cast. West side of Long Sleddale, Lake District. Base of Coniston Flags. Lapworth's Collection.

1 *d*. Distal fragment, impression. Rig Burn, River Esk, near Langholm. Wenlock Beds. Geological Survey of Scotland, Edinburgh.

1 *e*. Long distal fragment, with apertures facing the observer. West of Wharfe, Lake District. Lower Coniston Flags. Sedgwick Museum.

2 *a—d.*—*Monograptus vomerinus*, var. *basilicus* (Lapworth). (Page 411.)

2 *a*. Typical specimen. Cutting, Wellfield, near Builth. Wenlock Shales (zone of *Cyrtog. Linnarssoni*). Lapworth's Collection.

2 *b*. Distal fragment. Wellfield, near Builth. Wenlock Shales. Lapworth's Collection.

2 *c*. Type specimen, figured Lapworth (in part), Ann. Mag. Nat. Hist. [5], vol. v, pl. iv, figs. 6 *a* and *b*. On same slab as fig. 2 *a*.

2 *d*. Proximal portion. Pencerrig, near Builth. Wenlock Shales (zone of *Cyrtog. Murchisoni*). Elles' Collection.

3 *a—d.*—*Monograptus vomerinus*, var. *gracilis*, Elles and Wood, nom. nov. (Page 411.)

3 *a*. Typical specimen, impression. Elliotsfield, S. Scotland. Riccarton Beds. Lapworth's Collection.

3 *b*. Proximal portion. Trecoed, near Builth. Wenlock Shales (zone of *Cyrtog. Murchisoni*). Elles' Collection.

3 *c*. Broad distal fragment, impression. On same slab as fig. 3 *b*.

3 *d*. Proximal fragment, impression. Pencerrig, near Builth. Wenlock Shales (zone of *Cyrtog. Murchisoni*). Elles' Collection.

4 *a—d.*—*Monograptus vomerinus*, var. *crenulatus* (Törnquist). (Page 412.)

4 *a*. Distal fragment, partly in relief. Tarannon River, just below Dolgau Farm. Dolgau Beds. Wood's Collection.

4 *b*. Similar fragment, partly in relief. Ibid.

FIGS.

4 *a—d.*—*Monograptus vomerinus*, var. *crenulatus* (Törnquist). (Page 412)—*continued.*

4 *c*. Proximal portion, in relief. Ibid.

4 *d*. Fragment showing proximal end. Williamshope (?), S. Scotland. Gala Beds. Lapworth's Collection.

5 *a—d.*—*Monograptus griestoniensis* (Nicol). (Page 413.)

5 *a*. Proximal fragment, specimen on Nicol's type slab. Grieston Quarry, S. Scotland. Gala Beds. Geological Survey of England and Wales (11,800).

5 *b*. Distal portion. Ibid. (11,801).

5 *c*. Proximal portion, showing considerable curvature. Grieston Quarry. Gala Beds. Sedgwick Museum.

5 *d*. Ibid.

6 *a*, *b*.—*Monograptus* cf. *griestoniensis*. (Page 414.)

6 *a*. Proximal portion. Tarannon River. Talerddig Grits. Wood's Collection.

6 *b*. Longer specimen, showing rigid form. Afon-cwm-calch, near Talerddig Railway Cutting. Talerddig Grits (upper part). Wood's Collection.

7 *a—e.*—*Monograptus crenularis*, Lapworth. (Page 414.)

7 *a*. Long median fragment. Dobb's Linn. Upper Birkhill Shales (zone of *Cephalog. cometa*). Lapworth's Collection.

7 *b*. Long distal fragment, impression. The Corrie, Dobb's Linn. Upper Birkhill Shales. Lapworth's Collection.

7 *c*. Distal fragment, part in relief, part impression. Ibid.

7 *d*. Proximal fragment. Ibid.

7 *e*. Ibid.

MONOGRAPTUS.

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